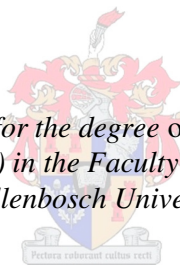


**Value-adding Business Process Modelling:  
Determining the suitability of a Business Process Modelling  
Technique for a given application.**

by  
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(Engineering Management) in the Faculty of Industrial Engineering at  
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Date: September 2013

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# ABSTRACT

Organizations formally define and document their business processes in order to properly understand them and to subsequently enable their continuous development, improvement and management. In order to formally define and document their business processes, organizations can use Business Process Modelling, which represents the design of graphical models that portray the business processes of organizations.

It is however noted that it is difficult to select a suitable Business Process Modelling Technique in support of a specific application of Business Process Modelling. This is due to the considerable amount of existing Business Process Modelling Techniques, the inherent impact of their varying capabilities and the lack of formal measures that are available to support evaluations regarding their suitability for specific modelling applications.

It is therefore considered appropriate to execute a research study that is aimed at the development and validation of a measurement framework that can be used to evaluate the suitability of Business Process Modelling Techniques for specific modelling applications.



# OPSOMMING

Organisasies definieer en dokumenteer hulle besigheidsprosesse op 'n formele wyse om hulle ordentlik te verstaan en gevolglik hulle deurlopende ontwikkeling, verbetering en bestuur te bemagtig. Ten einde die uitvoering van hierdie aktiwiteit aan te spreek, kan organisasies Besigheidsproses Modelling gebruik om grafiese modelle van hulle besigheidsprosesse te ontwerp.

Daar word egter kennis geneem dat dit moeilik is om 'n geskikte Besigheidsproses Modelling Tegniek te kies tes ondersteuning van 'n spesifieke toepassing van Besigheidsproses Modelling. Dit is weens die groot hoeveelheid bestaande Besigheidsproses Modelling Tegnieke, die impak van hulle variërende vermoëns asook die gebrek aan formele maatstawwe wat gebruik kan word om hulle geskiktheid vir spesifieke modellering toepassings te evalueer.

Dit lei tot die besluit om 'n studie te voltooi wat gefokus is op die ontwikkeling en validasie van 'n metings raamwerk wat gebruik kan word om die geskiktheid van Besigheidsproses Modelling Tegnieke vir spesifieke toepassings van Besigheidproses Modelling te evalueer.

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# CHAPTER 1: INTRODUCTION

## 1.1. BACKGROUND

*This section introduces the relevance of the researched field. It also provides the groundwork for the development of the research topic, problem definition and problem statement.*

### 1.1.1. BUSINESS PROCESSES

During the last two decades the field of business research has exhibited a renewed focus concerning the role of business processes within organizations. This focus has been encouraged by the acceptance among business experts that business processes are significant for modern organizations and represent key enablers of both their strategic and operational objectives.

This acceptance originates from the current business environment, which has been characterized by a continuous increase in the complexity of customer needs and the competition found within most industries. These characteristics have led to the realization that in order to prosper amidst this higher complexity and competition, organizations should adopt a customer-centric perspective and consequently align their strategic and operational objectives with the needs of their customers. In turn, organizations must ensure that their activities are of value to their customers and serve as means to achieve their strategic and operational objectives. Kress captured the importance of these actions when he stated that “ the company’s sustainable competitive advantage derives from its capacity to create value for customers and to adapt the operational practices to the changing situation ” [1].

The current and prominent tendency among customer-centric organizations is to select business processes as the means according to which they structure their activities for the aforementioned purposes. This tendency has been motivated by the fundamental nature and overall focus of business processes. The fundamental nature of business processes motivates their relationship with customer centricity given that they consist of “ logically ordered sets of activities that produce a result of value to the customer ” [Muhlen & Indulska, 2]. These sets are derived from the strategic and operational objectives of organizations. In addition, they are designed in such a way that the execution of their included activities leads to an accumulation of value for their associated customers. The end result of this design is that business processes deliver the total accumulated value to their final customers.

Based on their derivation from the strategic and operational objectives of organizations, business processes are not focused on isolated functional (or departmental) objectives or the sub-optimization of their related entities. Instead, they are focused on the overall integration and holistic performance of organizations. Business processes therefore adopt a “big picture” view and are intended to enable the strategic and operational objectives from which they were derived. Weske examined their intent and identified that each business process “depicts a set of activities performed in an organization that jointly realize a business goal” [3]. Tregear also examined their intent and acknowledged that “organizations execute their strategic intent via business processes” [4]. These identified properties associated with the fundamental nature and overall focus of business processes therefore promote the acceptance that “value-adding business processes have become more and more the principle of organizing the business” [Aquilar-Saven, 5].

Within the organizations that adopt a process orientation, business processes denote the means according to which all their operations are defined and essentially describe the way they conduct their business. In this regard, business processes symbolize “the blueprints of the organization that will directly contribute to the success or failure of the enterprise” [Perez-Castillo et al., 6]. Given this attributed impact, the relevance of business processes as a current research focus is warranted and it encourages an investigation into the core concepts related to their existence. This leads to an examination of Business Process Management, which represents the method used to develop and manage business processes within organizations.

### **1.1.2. BUSINESS PROCESS MANAGEMENT**

In light of the mentioned characteristics of the current business environment, adopting a process orientation cannot be seen as a single endeavor. Bibiano et al. declared that “management must constantly review and re-align organizational processes to reflect the massively unfixed nature of business demands” [7].

This introduces the realization that it is important for organizations to continuously define, understand, implement, execute, measure, analyze, improve and control their business processes. This is required to ensure the continued relevance of their business processes as well as the sustainability of their process-oriented business systems. It is identified that these actions are formally addressed by the concept of Business Process Management. According to the Australian Business Process Management Community of Practice, Business Process Management is “a structured, coherent and consistent way of understanding, documenting, modelling, analyzing, simulating, executing and continuously changing

end-to-end business processes and all involved resources in light of their contribution to business improvement “ [8]. The focus of Business Process Management is therefore recognized to be on the continuous development, improvement and management of business processes. This focus consequently motivates the use of Business Process Management in this regard.

It is noted that the implementation of Business Process Management is influenced by the sequence of its included actions. It is identified that organizations must first understand their current business processes before they can successfully implement, execute, measure, analyze, improve and control these units. Ramias & Wilkins commented that “ an organization can’t manage what it can’t see. That is, an organization cannot manage its processes – much less be process-centered, if it doesn’t understand its own processes. But whatever you elect to call it, a prerequisite to becoming process-centered is a clear, complete, logical and accurate view of how a given organization does its vital work ” [9].

This leads to the recognition that organizations should formally define and document their “ as-is “ business processes. This is required to properly understand these units and subsequently enable their proper and continuous development, improvement and management. In relation to this need, it is then necessary to identify a method that can be used to define and document the business processes of organizations. This consequently prompts an exploration of the methods available to define and document business processes.

### **1.1.3. BUSINESS PROCESS MODELLING**

Business Process Modelling is a popular method used to define and document business processes. It represents an important best practice [Accuprocess, 10] that is used to create graphical models of business processes.

Cousins & Stewart motivated the significance of business process models and proclaimed that “ an organization’s business processes are best described by means of a business process model “ [11]. Paradiso added that they “ illustrate the essential details of a process in a way that written procedures cannot “ [12]. The noted popularity of business process models is owed to their related benefits. These benefits surpass the basic ability to define and document business processes and include the visual portrayal of process features such as inter-functional communication, resource requirements and sequential constraints. It is identified that the visual portrayal of these types of features provides additional support with regard to understanding, implementing, executing, measuring, analyzing, improving and controlling business processes. Mendling acknowledged this and remarked that business process models are the “ conceptual artefacts underpinning the management of organizational

processes” [13]. Burlton commented that “great process organizations use that single map for all purposes” [14].

Business Process Modelling has therefore evolved into an important method used to define and document business processes [Born et al., 15]. In addition, the modelling of business processes is considered to be a “fundamental prerequisite for organizations wishing to engage in business process improvement and Business Process Management initiatives” [Indulska et al., 16]. Given these characteristics, the importance of Business Process Modelling is merited and it motivates an investigation into the core issues related to its use.

### 1.1.4. SUMMARY OF BACKGROUND

The diagram below represents a mindmap consolidating the perspectives of the preliminary research effort. These perspectives provide the groundwork for the development of the research topic, problem definition and problem statement.

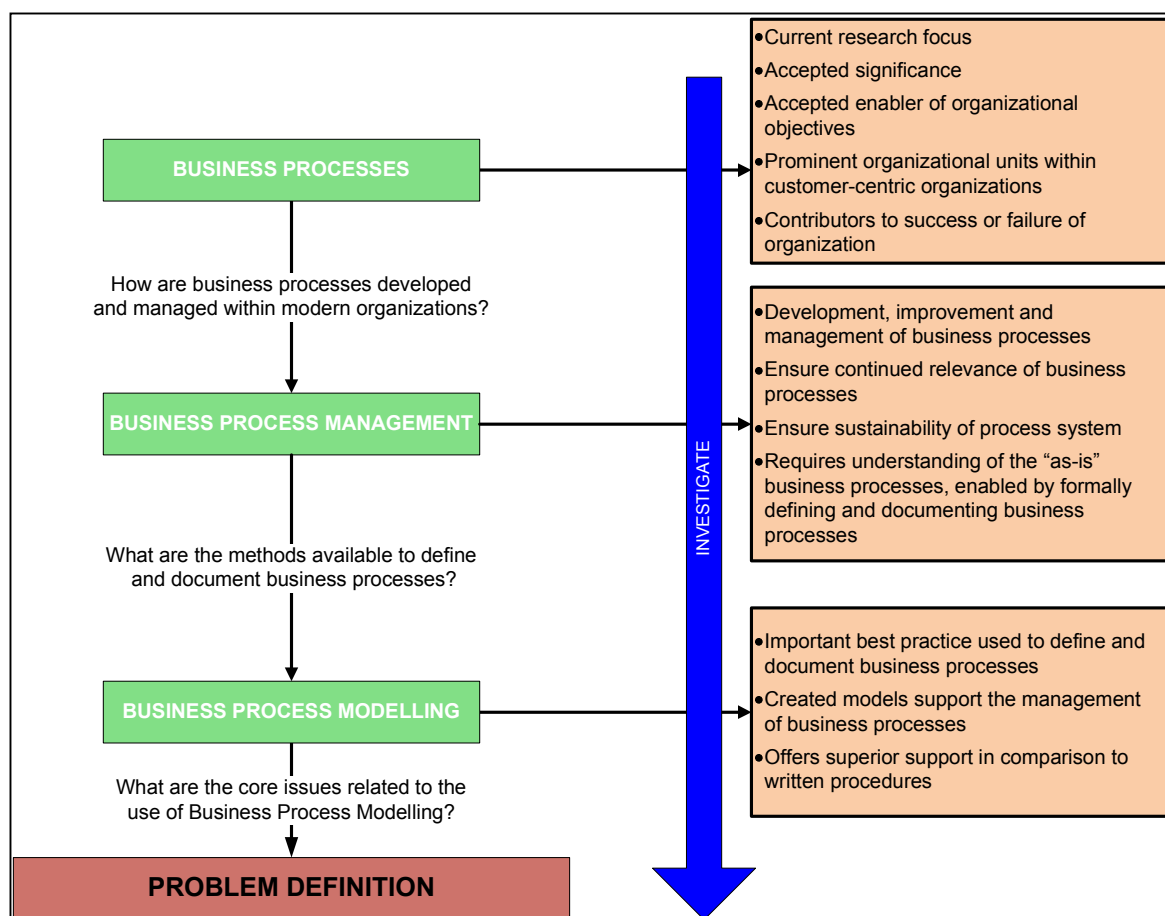


Diagram 1: Groundwork – Research Topic, Problem Definition and Problem Statement

## **1.2. RESEARCH TOPIC**

*This section presents the research topic, problem definition and problem statement.*

### **1.2.1. VARIETY OF BUSINESS PROCESS MODELLING TECHNIQUES**

There is a large variety of Business Process Modelling Techniques available to support the application of Business Process Modelling. Recker commented that “modelling techniques are like sand on the beach. They seem to exist in millions of variants, fashions and styles” [17]. These techniques each use a specific depiction language to capture and address the different aspects of business processes [Vergidis et al., 18]. In turn, these depiction languages cause varying strengths and weaknesses pertaining to the use of each technique.

The impact of the considerable amount of available techniques and their varying capabilities is that it becomes difficult to select a technique for a specific application of Business Process Modelling. Glassey observed that “this variety of techniques can be somewhat confusing, and the choice of an adequate technique for a given project might be difficult” [19]. In addition, current research efforts and application trends tend to suggest that there is not a single technique that is consistently selected or that is considered the superior technique for all modelling applications.

It is therefore identified that the task of selecting a Business Process Modelling Technique for a specific modelling application remains a major challenge related to the use of Business Process Modelling.

### **1.2.2. MEASURING THE SUITABILITY OF BUSINESS PROCESS MODELLING TECHNIQUES**

Regarding the task of selecting a Business Process Modelling Technique, the aim should be to identify and select the most suitable one for each modelling application. In order to identify and select such a technique, it is necessary to evaluate the suitability of all the techniques that are considered for the relevant application. The suitability of these techniques is evaluated based on the quality characteristics related to their depiction languages and their subsequent abilities to address the requirements of the specific modelling application.

It is however noted that these quality characteristics are often evaluated in an isolated, uncoordinated, inconsistent and unclear manner. In relation to this, there are insufficient proposals concerning an approach to execute these evaluations. It is further recognized that there is a lack of formal measures to

properly quantify the impact that these quality characteristics have on the abilities of their related techniques. Given these deficiencies, it becomes difficult to evaluate the suitability of the techniques that are considered for a specific modelling application.

It is therefore identified that it remains a required research outcome to develop a formal measurement framework that can be used to evaluate the suitability of Business Process Modelling Techniques for specific modelling applications.

### **1.2.3. PROBLEM DEFINITION**

Based on the identified challenges, the following actions are required:

- Develop a measurement framework that can be used to evaluate the suitability of Business Process Modelling Techniques for specific modelling applications.
- Validate the use of this measurement framework and determine the most suitable Business Process Modelling Technique for a specific modelling application.
- Model the “ as-is ” business processes related to the specific modelling application.

### **1.2.4. PROBLEM STATEMENT**

Based on the problem definition and the preceding perspectives, the following problem statement is generated:

***Ho: The suitable choice of a Business Process Modelling Technique and the implementation thereof will form the foundation for the continuous modelling and management of an organization’s business processes.***

## **1.3. RESEARCH DESIGN**

***This section presents an overview of the approach followed to execute the required research study.***

### **1.3.1. POINT OF DEPARTURE**

The problem definition represents the starting point for the research design. It prompts the need to conduct an in-depth empirical study. The purpose of this study is to successfully execute the actions stipulated by the problem definition.

### **1.3.2. EXECUTE LITERATURE REVIEW**

The empirical study is initiated by a comprehensive literature review. The objectives of the literature review are the following:

- Isolate and define the key definitions, concepts and methods relevant to Business Process Modelling. These entities provide the considerations that are necessary to guide the execution of the ensuing research activities.
- Identify and describe the more renowned, researched, applied, benchmarked and motivated Business Process Modelling Techniques currently available. This provides the platform to identify and select the group of techniques that are considered for the specific modelling application.
- Identify and describe the more prominent quality characteristics related to the depiction languages of Business Process Modelling Techniques. This provides the platform for the development of a formal measurement framework that can be used to evaluate the suitability of Business Process Modelling Techniques for specific modelling applications.

### **1.3.3. DEVELOP MEASUREMENT FRAMEWORK**

Based on the outputs of the literature review, a formal measurement framework is developed.

This framework is used to evaluate the suitability of the techniques that are considered for the specific modelling application.

### **1.3.4. IDENTIFY MODELLING APPLICATION**

In order to identify, understand and address the requirements of the ensuing research activities, the specific modelling application is identified and described.

### **1.3.5. SELECT GROUP OF CONSIDERED TECHNIQUES**

Based on the outputs of the literature review and the scope of the specific modelling application, an appropriate group of techniques is identified and selected. This group denotes the techniques that are considered for the specific modelling application.



### **1.3.6. COLLECT DATA**

In order to model the “ as-is ” business processes related to the specific modelling application, the data relevant to these units is collected. The collected data is a hybrid of primary and secondary data.

The following activities are executed to collect the primary data:

- Observe occurrences of the “ as-is ” business processes. The purpose of this activity is to gain an external perspective regarding the processes, activities and tasks relevant to the specific modelling application.
- Interview the process participants. The process participants represent managers, process-owners and staff relevant to the “ as-is ” business processes. The purpose of this activity is to capture the thoughts of the process participants and ultimately gain an internal perspective regarding the processes, activities and tasks relevant to the specific modelling application.

This is achieved through:

- Formal interviews
- Structured and self-administered questionnaires.
- Conversations or informal interviews

The following sources are used to collect the secondary data:

- Business correspondence
- Business reports and statements
- Business policies, strategies and regulations

The purpose of the secondary data is to support the primary data by providing additional details and considerations regarding the “ as-is ” business processes of the specific modelling application.

### **1.3.7. DESIGN BUSINESS PROCESS MODELS**

Based on the collected data, draft versions of the required business process models are designed.

The completion of this activity triggers the need to verify and refine the information portrayed by the draft business process models. This requires further fieldwork, collaboration with the relevant process participants as well as additional reviews of the secondary data sources. The completion of this verification and refinement prompts the design of the final business process models.

It is important to note that all of the considered techniques are respectively used to design distinct sets of business process models. The purpose of these distinct sets is to enable equivalent evaluations regarding the relevant techniques and their related abilities. These equivalent evaluations provide the platform to objectively compare the considered techniques in terms of their suitability for the specific modelling application.

### **1.3.8. MEASURE THE SUITABILITY OF THE BUSINESS PROCESS MODELLING TECHNIQUES**

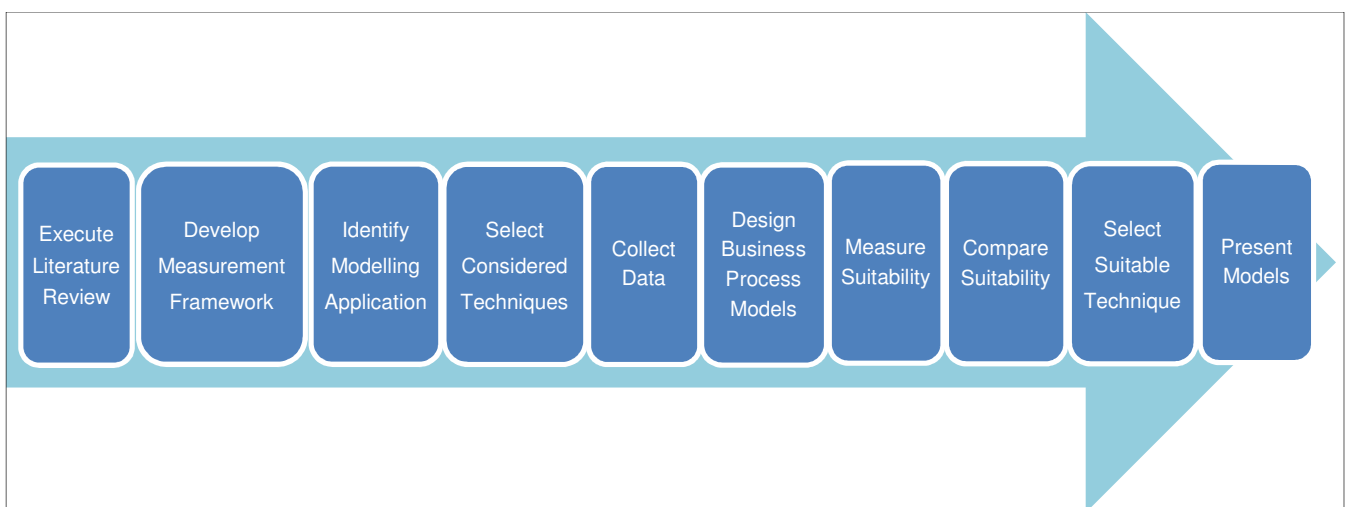
Upon completion of the design of the final business process models, the suitability of each of the considered techniques is measured using the developed measurement framework.

### **1.3.9. SELECT THE MOST SUITABLE BUSINESS PROCESS MODELLING TECHNIQUE**

Based on the outputs of the suitability evaluations, the considered techniques are compared and the most suitable technique is selected for the specific modelling application. The set of business process models that are designed through the use of the selected technique signifies the most suitable representation of the “ as-is ” business processes related to the specific modelling application.

### **1.3.10. SUMMARY OF RESEARCH DESIGN**

The diagram below provides a summary of the approach followed to execute the required research study:



**Diagram 2: Summary – Research Design**

## 1.4. OUTLINES OF CHAPTERS

*This section recapitulates the outline of Chapter 1 and presents the outlines of the remaining chapters.*

- **Chapter 1** introduced the relevance of the researched field, the research topic, the problem definition and the problem statement. It also gave an overview of the approach followed to execute the required research study.
- **Chapter 2** presents the outputs of the literature review. These outputs signify the definitions, concepts, methods and techniques that are necessary to guide the execution of the ensuing research activities.
- **Chapter 3** describes the research design and its implementation.
- **Chapter 4** describes the conclusions and recommendations of the research study.

# CHAPTER 2: LITERATURE REVIEW

## 2.1. LITERATURE SCOPE

*This section presents the scope of the literature review as well as the methods that are used to arrange the reviewed literature.*

The literature review is focused on recent, credible and significant literature relevant to Business Process Modelling. The purpose of this focus is to ultimately identify and describe the definitions, concepts, methods and techniques that are necessary to guide the execution of the ensuing research activities.

### 2.1.1. DEFINITIONS, CONCEPTS AND METHODS

The definitions, concepts and methods encountered during the literature review are separated into two groups. These groups provide the following respective functions:

- **Group A - Primary Function**
  - Includes the key definitions, concepts and methods that are necessary to guide the execution of the ensuing research activities.
- **Group B - Secondary Function**
  - Includes the definitions, concepts and methods that are used solely to support the primary literature.

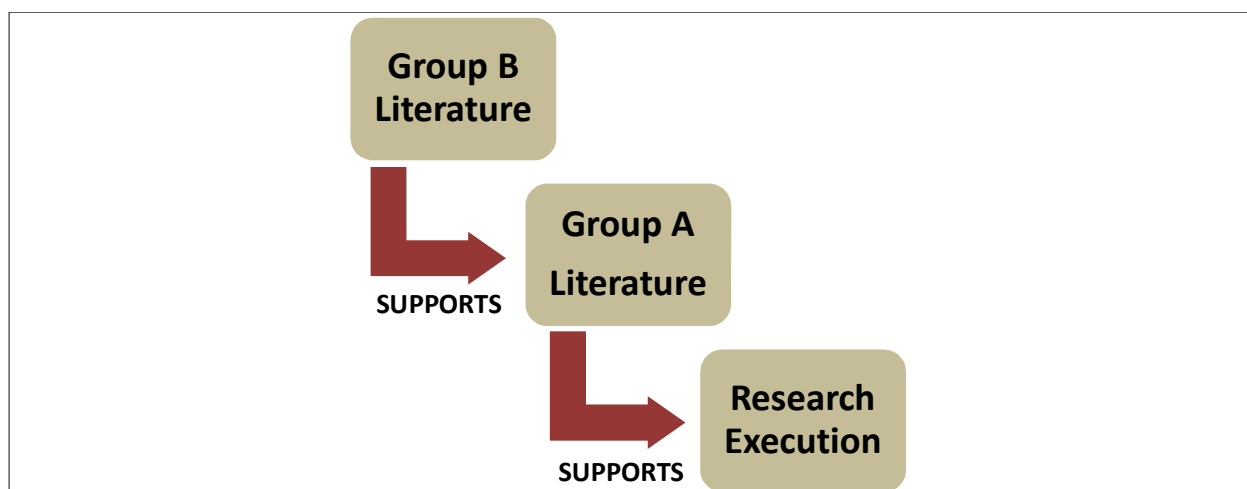


Diagram 3: Literature – Grouping of Definitions, Concepts and Methods

Motivated by these functions, the literature allocated to “ Group A ” is included in the summary of the literature review. The literature allocated to “ Group B ” is not included in the summary of the literature review, but a list of these definitions, concepts and methods is available in *Addendum 1*.

## **2.1.2. BUSINESS PROCESS MODELLING TECHNIQUES**

It has been mentioned that there is a considerable amount of Business Process Modelling Techniques available to support the application of Business Process Modelling. Given the scope and time-limit of the research study, it is impractical to describe and evaluate all of these techniques.

It is considered appropriate to reduce the techniques encountered during the literature review to a group of techniques that can be described and evaluated in accordance with the scope and time-limit of the research study. The method used to determine which techniques should be included in this group is to focus on the more renowned, researched, applied, benchmarked and motivated techniques currently available. This group of described and evaluated techniques provides the platform to ultimately identify and select the group of techniques that are considered for the specific modelling application.

In relation to this method and its subsequent focus, the following groups of techniques are identified:

- **Group 1 – Encountered Techniques**
  - Includes all the Business Process Modelling Techniques encountered during the literature review.
- **Group 2 – Described Techniques**
  - Includes all the Business Process Modelling Techniques that are described and evaluated.
- **Group 3 – Considered Techniques**
  - Includes all the Business Process Modelling Techniques that are considered for the specific modelling application.
- **Group 4 – Suitable Technique**
  - Includes the Business Process Modelling Technique that is considered the most suitable for the specific modelling application.

The techniques allocated to “ Group 2 ” are included in the summary of the literature review. This group also contains the techniques that will later form part of “ Group 3 ” and “ Group 4 ”. The techniques that

are contained within “ Group 1” and excluded from “ Group 2 “ are not included in the summary of the literature review, but a list of all the encountered techniques are available in *Addendum 2*.

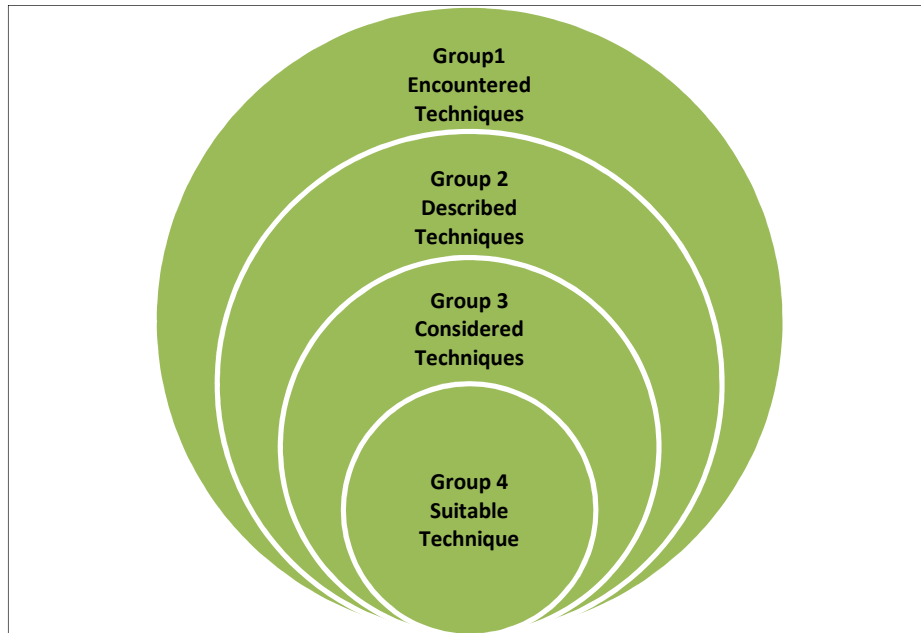


Diagram 4: Literature - Grouping of Business Process Modelling Techniques

## 2.2. SUMMARY OF LITERATURE STUDY

*This section presents the key definitions, concepts and methods relevant to Business Process Modelling. It also describes the more renowned, researched, applied, benchmarked and motivated Business Process Modelling Techniques currently available.*

### 2.2.1. KEY DEFINITIONS, CONCEPTS AND METHODS

#### 2.2.1.1. DEFINITION OF A BUSINESS PROCESS

In order to understand the fundamental nature of a business process, it is important to identify its definition. This is achieved through a review and consolidation of the definitions that have been presented by business experts during the last two decades. In turn, the review and consolidation of these definitions provides the groundwork to identify an initial set of core characteristics related to business processes.

In the year 1990, Davenport & Short initiated the modern discussion regarding the definition of a business process and described the aforementioned as “ a set of logically related tasks performed to

achieve a desired business outcome ” [20]. In the same year, Hammer stated that a business process is “ a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer ” [21].

Examining the definition by Davenport & Short, the following is identified:

- There is a logical relationship between the tasks contained within a business process.
- The outputs of a business process are desired business outcomes or objectives.

In comparison, the definition by Hammer discloses that:

- Certain inputs are transformed into desired outputs through the execution of the activities contained within a business process.
- The outputs created by a business process should be of value to customers.

Davenport later complemented Hammer’s output perspective and defined a business process as a “ structured and measured set of activities designed to produce a specific output for a particular customer or market ” [22]. Hammer & Champy initially persisted with Hammer’s earlier definition [21], but they later added that a business process is “ a set of partially ordered activities intended to reach a goal that is affected by events occurring in the external world or in other processes ” [23]. This definition leads to the realization that:

- The activities contained within a business process are influenced by variables that stem from entities external to the organization or from other business processes within the organization.

Johansson et al. defined a business process as “ a set of linked activities that takes an input and transforms it to create an output. Ideally, the transformation that occurs in the process should add value to the input and create an output that is more useful and effective to the recipient either upstream or downstream ” [24]. This definition covers most of the views of the earlier versions. It also introduces the following views:

- Internal entities (or internal customers) within an organization can also be the recipients of the outputs of a business process. This deviates from the notion that the outputs of a business process are only intended for external customers. Related to this view, Rummler & Brache encouraged a definition that clearly surpasses a focus on the organization’s external customers. They stated that “ a business process is a series of steps designed to produce a product or service. Some processes result in a product or service that is received by an organization's

external customers while other processes produce products and services that are invisible to the external customer but essential to the effective management of the business “ [25].

- The structure of a business process is designed to accumulate value. Aligned with this view of value addition, Cousins & Stewart identified a business process as “ a set of activities that create the value chain of an organization and associate that value chain with the requirements of the customer ” [11].

The Workflow Management Coalition commented that a business process is “ a set of one or more linked procedures or activities which collectively realize a business objective or policy goal, normally within the context of an organizational structure that defines functional roles ” [26]. This definition shares the view of Davenport and Short [20] regarding the relationship between a business process and certain desired business outcomes or objectives. It also highlights that:

- There are functional roles and responsibilities associated with the activities contained within a business process.

In contrast to the more detailed definitions, various versions have been documented that are of a condensed and candid nature. Jacobson defined a business process simply as “ the way an organization acts on itself and on its environment ” [27]. Harvey defined a business process as “ step-by-step rules specific to the resolution of a business problem ” [28]. Laguna and Marklund added that “ from a pragmatic point of view, a business process describes how something is done ” [29].

In the last few years some business experts have defined a business process in similar ways as the earlier pioneers. Muehlen & Indulska explained business processes as “ logically ordered sets of activities that produce a result of value to the customer ” [2]. This basically signifies a confirmation of the earlier view produced by Hammer [21]. Aligned with the definition by Davenport & Short [20], Draheim described a business process as “ a net of activities that work together to achieve a defined goal ” [30].

In addition to their abbreviated version, Laguna and Marklund provided a more detailed definition that advocated business processes as “ networks of connected activities with well-defined boundaries and precedence relationships, which utilizes resources to transform inputs into outputs for the purpose of satisfying customer requirements ” [29]. This definition identifies that:

- There are well-defined boundaries related to each business process and its related activities.
- There are well-defined precedence relationships between the activities contained within a business process.



- Resources are used by a business process to transform certain inputs into desired outputs.

Consolidating all of the preceding definitions, the following definition regarding a business process is identified:

*Structured and related set of activities, with well-defined precedence relationships and boundaries, that uses resources to transform inputs into outputs that are of value to either internal or external customers.*

### 2.2.1.2. CHARACTERISTICS OF BUSINESS PROCESSES

Based on the reviewed and consolidated definitions, an initial set of core characteristics related to business processes are identified. The graph below provides a mindmap consolidating this set of characteristics:

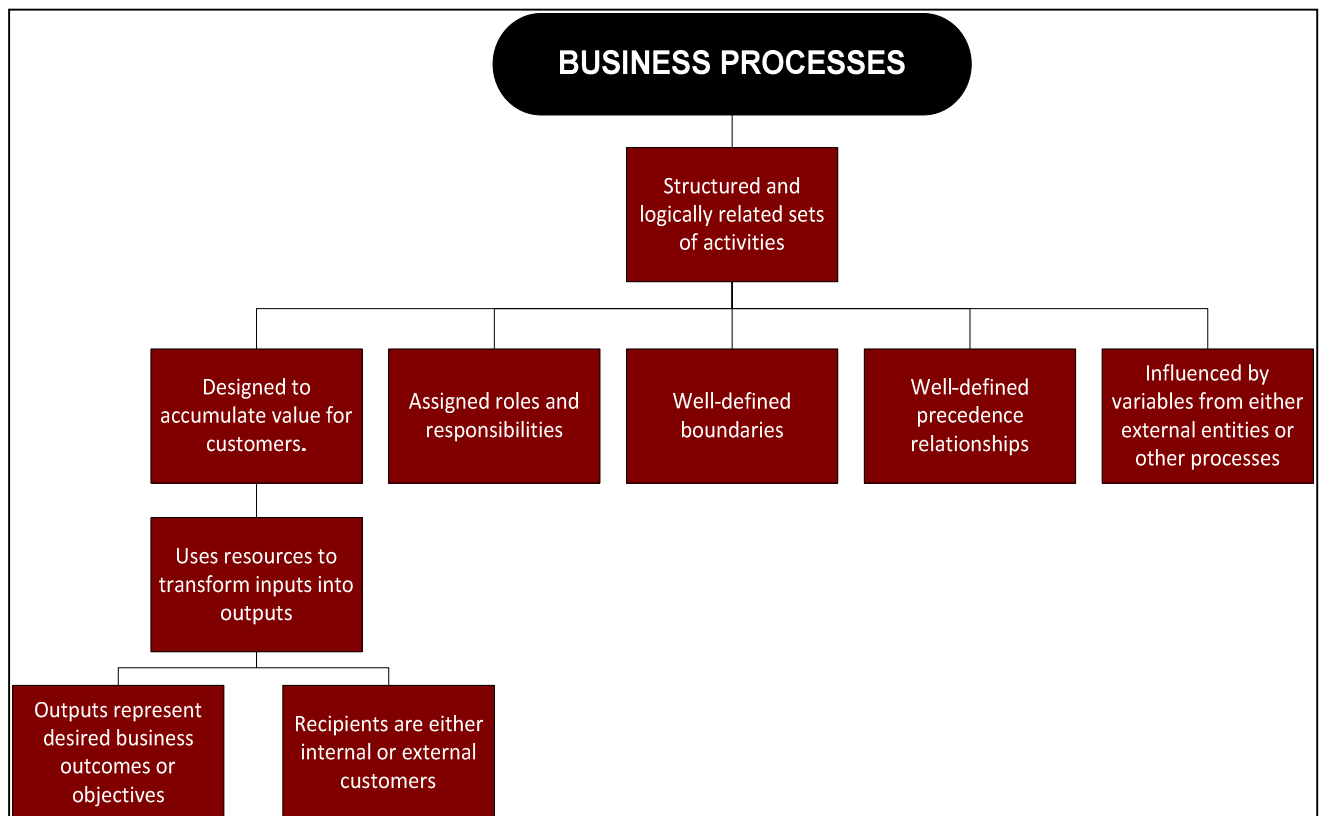


Diagram 5: Business Processes – Initial Set of Core Characteristics

The rest of this section presents a discussion of some of these characteristics and other topics relevant to business processes.

#### **2.2.1.2.1. ELEMENTS OF BUSINESS PROCESSES**

Based on the efforts of Davenport [22], Hammer & Champy [23], Laguna & Marklund [29], Lin et al. [31], Guo & Zou [32] and Aldin & De Cesare [33], a combination of generally accepted business process elements are identified. These elements are:

- **Boundaries**

Within the organizations that adopt a function perspective, the activities that they perform are structured according to specific functional divisions (or departments) that are usually equipped with staff dedicated only to particular functions. This structure is often associated with a focus that is on the isolated execution of the activities within these divisions instead of a focus that is on the larger value chains that exist within these organizations. Organizations that are fixated on these divisions and their related activities often suffer from a silo syndrome [Gourishankar, 34]. This is commonly characterized by a lack of coordination and communication among their various divisions. These characteristics facilitate the existence of duplications, delays, confusion, errors and other issues detrimental to the efficiency of their operations. In addition, the inclination to underline the objectives of these divisions instead of the overall objectives of their organizations ultimately inhibits the overall effectiveness of their operations.

According to Magal & Word, “ a major challenge facing organizations is to effectively coordinate the activities among the different functions or departments “ [35]. In order to address this challenge, many organizations use business processes as the units according to which they structure their activities. These organizations therefore adopt a process orientation, which signifies a horizontal perspective concerning their activities as well as the alignment of all their organizational systems according to the structure of business processes [Hernaes, 36].

In relation to their horizontal perspective, business processes reach over the confines of functional divisions and represent the larger value chains within organizations. In this regard, they symbolize the way in which organizations provide value to their customers without regard to functional divisions [11]. The boundaries of business processes are therefore defined in accordance with the specific value chains that they represent within organizations, which span from the start of these value chains until their conclusion. The graph below depicts the respective boundaries of business processes and functional divisions:

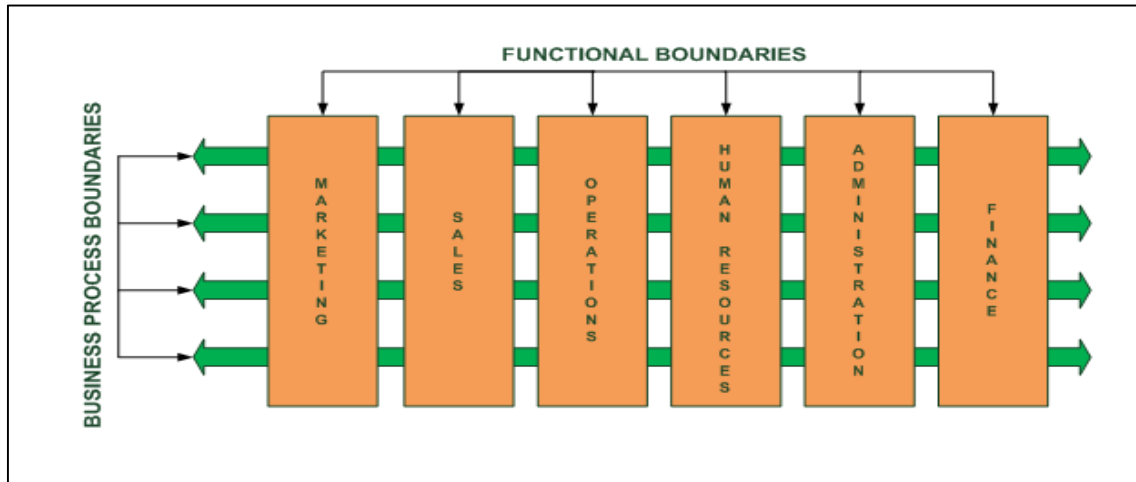


Diagram 6: Business Processes - Defined Boundaries [1]

- **Activities**

It has been mentioned that a business process consists of a set of structured and related activities.

These activities represent coherent operations that are structured and executed in accordance with the chronological order stipulated by their associated business process definition [Seshan, 37].

With reference to this chronological order, the execution of each activity within the set partly contributes to the completion of the associated business process.

The activities contained within a business process may each consist of a set of tasks (or sub-activities).

These tasks represent the lowest level of decomposition associated with a business process [37] and are also structured and executed according to a stipulated order [Debenhaum, 38]. In turn, the execution of each task within such a set partly contributes to the completion of the associated activity. The graph below illustrates the levels of decomposition associated with a business process:

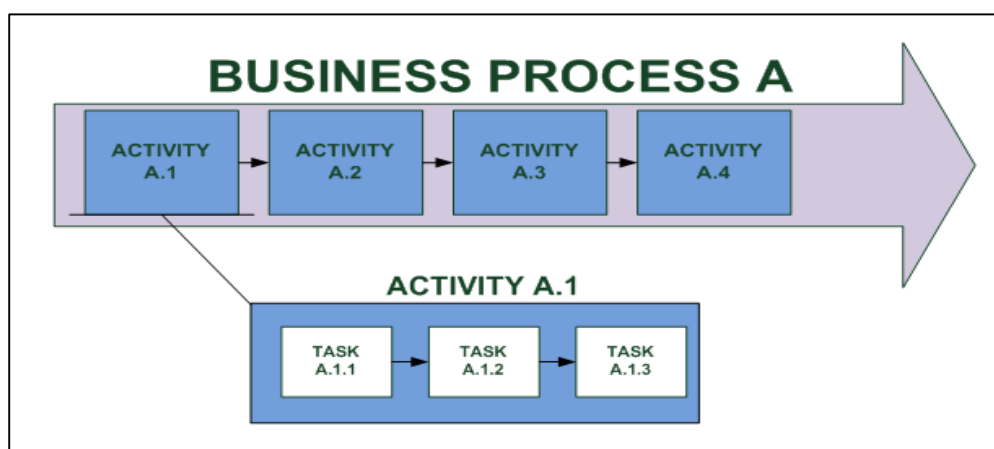


Diagram 7: Business Processes - Levels of Decomposition [1]

The chronological order stipulated for a set of activities or a set of tasks signifies the defined precedence relationships that exist among its units. These precedence relationships lead to interdependencies among the activities or tasks that are contained within a business process or activity respectively. It is also noted that a business process may include activities and tasks from other business processes, which can be either internal or external to the organization. In this regard, there may also be interdependencies among both the activities and tasks of different business processes and organizations.

In relation to these interdependencies, the delay of one activity or task can lead to the delay of its succeeding activities or tasks. This chain of delays can have a detrimental impact on the efficiency and effectiveness of the associated business processes. Given this impact, it is important to determine the root causes of such delays and subsequently identify the solutions that can eradicate their existence. In this regard, the interdependencies that exist among activities and tasks represent important considerations related to the design, analysis, improvement and management of business processes.

- **Inputs**

Business processes use various types of inputs to create the desired outputs for their customers. These inputs can be of a tangible (i.e. data, raw materials) or intangible (i.e. information, knowledge, experience) nature. In addition, these inputs may represent the outputs of other business processes, activities or tasks.

There have been efforts by organizations to improve the way in which they use, store, retrieve and manage both their tangible and intangible inputs. These efforts have been motivated by the realization that these inputs can have a significant impact on the efficiency and effectiveness of their associated business processes. In relation to their tangible inputs, these efforts have included the development of systems related to the management of their data and materials. In relation to their intangible inputs, these efforts have included the development of systems related to the management of their information and knowledge. In relation to both their tangible and intangible inputs, these efforts have included the management of their quality as a component of a larger quality management system as well as the redesign of their associated business processes. These actions have been executed in an attempt to ensure that these respective inputs are of an adequate quality, that they are properly managed, that they are empowered by their associated business process designs to generate adequate outputs and that they are readily available during the execution of their associated business processes.

Ultimately, these characteristics are considered important to ensure that these inputs can support efficient and effective business processes.

- **Resources**

Resources signify the human, technological and infrastructural objects that organizations use to transform inputs into the desired outputs for their customers [12]. With reference to the current business environment, there are significant changes concerning the way in which organizations use their different types of resources. Organizations are increasingly researching, designing, acquiring and implementing advanced technological resources in an attempt to increase the levels of automation associated with their business processes. These efforts are focused on reducing the amount of human resources required by their business processes, particularly related to activities and tasks that are of a repetitive or tedious nature. Ultimately, the objective is to increase the available capacity of their human resources and to subsequently enable their use for more effective and valuable purposes. It is opinionated that the role of technological resources within organizations will continue to grow and they will become more and more responsible for the physical execution of tasks and activities. In turn, this will allow the use of organizations' human resources for higher level operations e.g. for the design, analysis and management of business processes.

- **Outputs and Objectives**

The execution of the activities and tasks contained within a business process is aimed at creating outputs that are of value to customers [31, 33]. Ideally, these activities and tasks should only be executed for these purposes [Thomas, 39] and their outputs should be aligned with the business objectives from which they were initially derived. It is therefore considered important for organizations to measure and analyze the outputs of these units. The purpose of this is to evaluate whether these outputs are truly of value to their intended customers and whether their associated activities and tasks are able to achieve their associated business objectives. In turn, activities and tasks that do not create outputs of value and that are not considered to be effective should be the focus of organizations' business process redesign efforts.

- **Customers**

Customers represent the recipients of the valuable outputs that are created by the business processes, activities and tasks within organizations. The customers of business processes, activities and tasks can represent entities internal or external to organizations, which is determined based on the position of the relevant unit within the broader business context [11].

Customarily, organizations focus on satisfying the needs of their external customers. Although these customers are important, it is also important for organizations to focus on satisfying the needs of their internal customers. Ideally, it should not matter whether the customers of outputs are external or internal to organizations and the same level of effort is expected to satisfy the needs of both these types of customers. In relation to this, it is vital to consider the needs of both these types of customers during the design and analysis of the business processes of organizations. This is considered vital to ultimately ensure the overall quality, integration and performance of their business processes, activities and tasks.

- **Responsibilities**

There are responsible entities associated with the execution of the activities and tasks that are contained within a business process. These responsible entities may represent people or applied technological systems [Gruchman, 40]. In the case where a business process consists of various activities or tasks, several responsible entities may be associated with its completion [Vos et al., 41].

It is fair to comment that a major issue within organizations that have not yet properly defined and documented their business processes is the lack of accountability associated with their business processes, activities and tasks. This lack of accountability commonly leads to confusion, frustration, “blame-shifting” and other issues detrimental to the efficiency and effectiveness of their operations. In relation to this issue, it is considered vital to define and document the business processes of organizations. This is vital in order to enable the entities involved to understand what their responsibilities are and how their contributions fit into the broader context of each business process.

- **Events**

Events exemplify “occurrences that take place at specific points in time and that is capable of inducing some observable behavior” [33]. Joosten identified this observable behavior as a specific commitment by an organization and that each event indicates the beginning of such a commitment and ends with the termination of that commitment [42]. The observable behavior or commitment associated with an event can be represented by a business process, activity or task. In addition, an event can originate from entities external to organizations or from other business processes, activities or tasks within organizations.

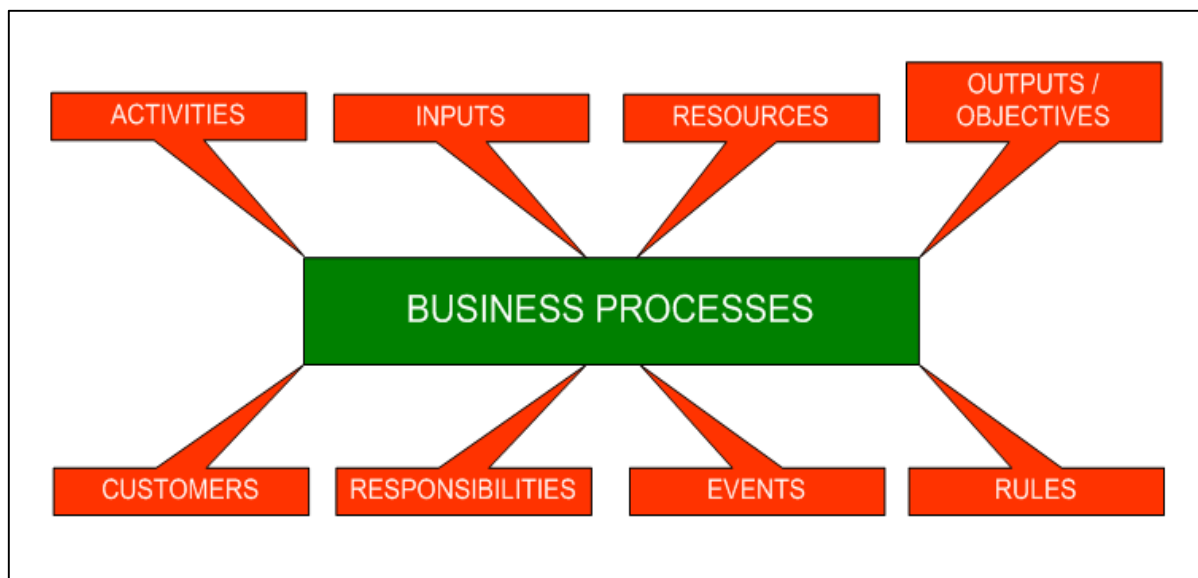
In relation to the design and analysis of business processes, organizations are attempting to predict and identify the range of events that may be associated with their operations. The purpose of this is to ensure that they are prepared to address most of these events. Ultimately, the preparedness of

organizations for these events can have a significant impact on their ability to satisfy the needs of most of their customers.

- **Rules**

Rules are described as “ constraints defined for any part of the organization and its relevant business processes ” [33]. These constraints vary in nature and may be influenced by various organizational characteristics, which include the type of industry, resource capacities and inter-organizational dependencies associated with the relevant organization. With reference to the type of industry, certain industries are subjected to laws and regulations that lead to constraints regarding the conduct and operations of their associated organizations. With reference to the resource capacities of organizations, upper-limits may perhaps be instilled on some of their operational capabilities. With reference to inter-organizational dependencies, the operations of an organization can be constrained as a result of their relationships with the operations of other organizations.

Rules or constraints can significantly impact the operations of organizations. It is therefore important for organizations to consider these elements during the design, execution, analysis and management of their business processes. This is important in order to ensure that organizations understand their operational limitations and subsequently design, execute, analyze, improve and manage their business processes in accordance with these operational limitations.



**Diagram 8: Business Processes –Summary of Elements [Adapted from [22], [23], [29], [31], [32], [33]]**

#### **2.2.1.2.2. BUSINESS PROCESS MATURITY LEVELS**

In order to unlock the full potential of their business processes, organizations must first understand the maturity of their business processes. In turn, they must identify what is required in order to elevate their business process maturity levels. Consolidating the efforts of Harmon [43] and Macintosh [44], five levels of business process maturity are defined. These levels are:

##### **1. The Initial Level**

This level represents the lowest level of maturity relevant to business processes. The business processes associated with this level of maturity signify ad-hoc sets of undefined activities, which are not yet of a repeatable or coherent nature. The success of these business processes rely heavily on the heroic efforts of the individuals within their associated organizations [43]. In relation to the complex and competitive nature of the current business environment, organizations that possess business processes associated with this level of maturity will most probably not be sustainable. It is therefore important for these organizations to establish business processes that are at least of a repeatable and coherent nature.

##### **2. The Repeatable Level**

This level represents the existence of business processes that are of a repeatable and coherent nature. Although these business processes are of a higher maturity than the business processes associated with the initial level, they have not yet been formally defined, documented and standardized. Organizations associated with this level of maturity therefore still lack clear and accurate descriptions concerning their business processes. This limits their ability to properly understand their business processes. In turn, it is important for organizations associated with this level of maturity to define, document and standardize their business processes.

##### **3. The Defined Level**

This level represents the existence of business processes that are defined, documented and standardized [44]. In relation to these executed actions and the associated level of maturity, organizations are empowered to properly understand their business processes. This provides them with the platform to continuously develop, improve and manage their business processes and process-oriented systems.

##### **4. The Managed Level**

This level represents the existence of a system of measured and controlled business processes [44]. Detailed measures are established for these business processes whereby their actual performance is



measured against certain predetermined performance targets. Based on the measured results, improvement opportunities are identified in order to address the gaps between the actual performance of these business processes and their predetermined targets. Controls are introduced to ensure that these business processes are executed in accordance with their definitions and standards. Although the maturity of these business processes is considered high, the focus of this level is on the control of business processes instead of a focus that is on the optimization of business processes. In addition, improvements and controls are mostly introduced as reactions to performance gaps and are not yet driven by proactive actions or a culture of continuous improvement.

### 5. The Optimized Level

This level represents the highest level of maturity relevant to business processes. The business processes associated with this level of maturity are continuously and consistently designed, implemented, executed, measured, analyzed, improved and managed. These actions are executed as part of a continuous improvement drive to generate optimal business processes and process-oriented systems. With reference to these business processes, improvement opportunities and innovations are proactively identified, initiated and accomplished.

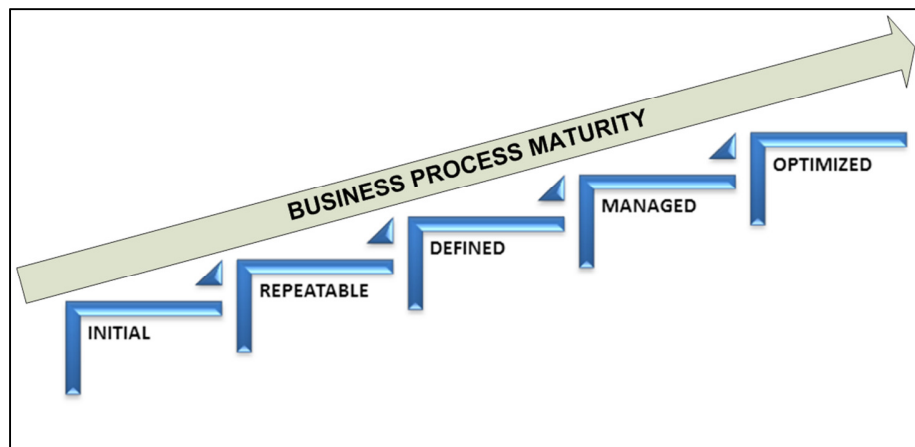


Diagram 9: Business Processes - Levels of Maturity [44]

It is identified that Business Process Modelling can play a significant role concerning the business process maturity of organizations. It can be applied to define, document and standardize repeatable business processes in order to elevate them to the defined level of business process maturity. It can also be applied to support the subsequent analysis, improvement and management of the business processes that are associated with the managed and optimized levels of business process maturity.

#### **2.2.1.2.3. TYPES OF BUSINESS PROCESSES**

There are three types of business processes commonly identified [Ould, 45]. They are:

##### **1. Management processes**

- Management processes represent the business processes that govern organizations [Rosenberg & Lund, 46] and that is focused on the planning of organizations at a business level [List & Korherr, 47]. They include business processes that are related to concepts such as Corporate Governance and Strategic Management.

##### **2. Core (Primary) processes**

- Core processes represent the business processes that constitute the core competencies and primary value chains of organizations [45]. The purpose of these business processes is to satisfy their ultimate external customers [46] and to add direct value to their organizations [Barn, 48]. They include business processes that are related to concepts such as Procurement and Sales.

##### **3. Support (Secondary) processes**

- Support processes represent the business processes that support the core processes within organizations [46]. The purpose of these business processes is to satisfy internal customers and to add indirect value to their organizations. They include business processes that are related to concepts such as Information Technology Support and Recruitment.

The classification of business processes according to these types is considered significant for organizations. In relation to their management processes, organizations can identify the business processes that are essential to their long-term direction, planning and culture. In relation to their core processes, organizations can isolate the business processes that drive external customer value and that are vital to their performance and existence. In relation to their support processes, organizations can identify the business processes that do not necessarily represent quantifiable value, but that are still essential to the success of the core business processes that they support.

Business processes can also be typified based on their scope within organizations [29]. These scope-based types are:

**A. Individual processes**

- Individual processes represent the business processes that are performed by individuals within organizations.

**B. Vertical (Functional) processes**

- Vertical processes represent the business processes that are performed by the functional divisions or departments within organizations.

**C. Horizontal (Cross-functional) processes**

- Horizontal processes represent business processes that are performed by various functional divisions or departments within organizations [29].

The classification of business processes according to these scope-based types can also play a significant role within organizations. In relation to their individual processes, organizations can identify the business processes that collectively represent a good starting point for future automation efforts. In relation to their vertical processes, organizations can analyze the business processes associated with their functional divisions. This enables them to identify the human resource requirements of their divisions in terms of competencies and skills. In relation to their horizontal processes, organizations can understand, analyze and improve the communication and coordination required between their various divisions.

In addition to the aforementioned classifications, Weske [3] introduced dimensions according to which business processes can be classified. These dimensions are:

**I. Organizational versus Operational**

- This dimension includes the classification of business processes according to their positions within the hierarchies of organizations. It spans the classification of business processes from high-level business strategies to implemented operational business processes [3].

**II. Intra-organizational versus Inter-organizational**

- This dimension includes the classification of business processes according to the nature of their relationships with other business processes. It spans the classification of business processes from those that are only related to internal business processes to those that are only related to external business processes.

### **III. Degree of Automation**

- This dimension includes the classification of business processes according to their level of automation. It spans the classification of business processes from those that are manually executed to those that are fully automated.

### **IV. Degree of Repetition**

- This definition includes the classification of business processes according to their frequency of occurrence [3]. It spans the classification of business processes from those that occur rarely to those that occur repeatedly.

### **V. Degree of Structuring**

- This definition includes the classification of business processes according to their level of defined structure. It spans the classification of business processes from ad-hoc and unstructured to those that are fully defined and structured.

The classification of business processes according to these dimensions can be useful to organizations. It can provide them with a profile of characteristics related to their business processes that can be used to identify improvement opportunities. The following examples indicate how organizations may possibly use these dimensions to identify improvement opportunities:

- With reference to the organizational versus operational dimension, organizations may perhaps identify that they possess well-defined operational business processes, but lack properly defined high-level business strategies and organizational business processes. They can subsequently develop and implement these strategies and business processes to drive their long-term direction, planning and culture.
- With reference to the intra-organizational versus inter-organizational dimension, organizations may well realize that their operations are heavily dependent on the operations of other organizations. They can subsequently implement controls to ensure that these interdependencies are properly managed in terms of reliability and risk.
- With reference to the degree of automation dimension, organizations might identify that most of their business processes are manually executed and that a lot of human resources are devoted to the execution of activities or tasks that can be automated. They can subsequently automate these activities or tasks and enable the use of their human resource for higher level operations.

- With reference to the degree of repetition dimension, organizations may perhaps identify that they have a small group of business processes that repeatedly occur and consume most of their resources. They can subsequently focus on these business processes during future improvement efforts. In turn, the improvement of these business processes can have a significant impact on the efficiency and effectiveness of their overall operations.
- With reference to the degree of structuring dimension, organizations may realize that the majority of their business processes are still of an ad-hoc and unstructured nature. They can subsequently define, document and standardize these business processes and improve their overall business process maturity.

#### **2.2.1.2.4. OBJECTIVES OF BUSINESS PROCESSES**

Based on the efforts of Davis [49, 50], specific objectives related to business processes are identified. These objectives represent motivations for the existence of business processes. They also represent important considerations regarding the design, measurement, analysis, improvement and management of business processes. These objectives are:

1. Business processes should be valuable to their customers.
2. Business processes should enable organizations to achieve their operational and strategic objectives.
3. Business processes should be valuable to their organizations.

Organizations identify and define specific operational and strategic objectives that they must achieve in order to steer their projected performance, competitiveness, success and sustainability.

They subsequently identify and define the operations that they must execute in order to achieve these objectives. This includes identifying and defining the valuable outputs that must be generated by these operations and the customers (internal or external) that must receive these outputs. Considering this from another perspective, process-oriented organizations require business processes that can generate outputs that address the needs of their customers and that are eventually valuable to their customers. In turn, they require business processes that enable them to achieve their operational and strategic objectives. Ultimately, they will regard these business processes as valuable given the impact that they have on their projected performance, competitiveness, success and sustainability.

Building on the above perspectives and the efforts of Davis [49], it is important for organizations to design, measure, analyze, improve and manage their business processes in such a way that they are:

- **Effective**
  - Business processes are effective when they create outputs that enable their organizations to achieve their objectives.
- **Relevant**
  - Business processes are relevant when they create outputs that are in accordance with the needs of their organizations' customers (internal or external).
- **Efficient**
  - Business processes are efficient when they create their outputs through the minimum possible use of organizational resources.
- **Valid and Usable**
  - Business processes are valid and usable when their execution is feasible and their outputs are achievable given the profiles of their associated organizations and the realities of their associated business environments.
- **Used and Re-used**
  - Business processes are used when they are understood, implemented and executed. Business processes are re-used when they are of a repeatable and logical nature.
- **Managed**
  - Business processes are managed when they are properly designed, implemented, executed, measured, analyzed, improved and controlled.

### **2.2.1.3. DEFINITION OF BUSINESS PROCESS MANAGEMENT**

In order to understand the fundamental meaning of Business Process Management, it is important to identify its definition. This is achieved by a review and consolidation of some of the most noteworthy definitions that have been documented during the last few decades. The review and consolidation of these definitions also provides the platform to identify a set of characteristics associated with Business Process Management.

Lee & Dale defined Business Process Management as a “ customer-focused approach to the systematic management, measurement and improvement of all company processes ” [51]. In concurrence with the essence of this definition, Van den berg et al. described Business Process Management as a

“ management discipline with an explicit aim to manage and optimize business processes to increase customer value “ [52]. The key perspectives extracted from these definitions are:

- It is a customer-oriented concept.
- It is a systematic concept.
- It involves the management, measurement and improvement of business processes.

These actions are executed in order to ensure that business processes deliver adequate value to their intended customers. It is important to note that the management of business processes indicates the parent action associated with Business Process Management. In turn, the measurement and improvement of business processes represent sub-actions contained within the management of business processes.

Van der Aalst et al. explained Business Process Management as “ a field of knowledge at the intersection between management and information technology, encompassing methods, techniques and tools, to design, enact, control and analyze operational business processes involving humans, organizations, applications, documents and other sources of information “ [53]. Based on this definition, it is identified that:

- Business Process Management includes the management of business processes through the use of various methods, tools and techniques, which are in some way supported by Information Technology.
- In addition to the measurement and improvement of business processes, Business Process Management also includes the design, execution and analysis of business processes.

Makhfi defined Business Process Management as “ a holistic management approach, a continuous process improvement engine that promotes business effectiveness and efficiency while striving for innovation, flexibility, and integration with technology “ [54]. The following view is derived from this definition:

- Business Process Management is focused on the holistic management, integration and performance of business processes, which subsequently contributes to the management, integration and performance of organizations.

The Australian Business Process Management Community of Practice identified Business Process Management as a “ structured, coherent and consistent way of understanding, documenting, modelling, analyzing, simulating, executing and continuously changing end-to-end business processes and

resources in the light of their contribution to business improvement ” [8]. This definition highlights the following relevant properties:

- Aligned with the systematic perspective introduced by Lee & Dale, it has an attributed structure that is of a coherent and consistent nature.
- In addition to the aforementioned actions, it also includes documenting, understanding, modelling and simulating business processes, which represent sub-actions contained within the management of business processes.

Consolidating all of the preceding definitions, the following definition related to Business Process Management is identified:

*Customer-focused approach that uses various methods, tools and techniques for the structured, coherent, consistent and holistic management of business processes.*

#### **2.2.1.4. CHARACTERISTICS OF BUSINESS PROCESS MANAGEMENT**

##### **2.2.1.4.1. ELEMENTS OF A PROCESS ORIENTATION**

There are many modern organizations that have adopted a process orientation [Zaheer et al., 55]. These organizations have adopted this orientation in an attempt to improve the efficiency and effectiveness of their operations [Mackay et al., 56]. In turn, they intend to accomplish this in order to improve their overall performance, competitiveness, success and sustainability. Based on the efforts of McCormack [57], there are five important concepts that organizations must consider when they want to adopt a process orientation. These concepts are:

##### **1. Process perspective**

The process perspective represents a “ management paradigm that defines an organization as a network of business processes ” [1]. In order to adopt a process orientation, organizations must therefore not be viewed and defined according to their functional divisions (or departments). Instead, they must be viewed and defined according to their business processes.

##### **2. Process structures**

In order to be viewed and defined according to their business processes, organizations must adopt business processes as their premier organizational units. This includes structuring and standardizing themselves in accordance with the elements of business processes, which includes inputs, activities, outputs, resources, responsibilities, customers, boundaries, rules and events.



### **3. Process jobs**

Related to the aforementioned concepts, organizations must also rethink the way in which they assign roles and responsibilities to their resources. These roles and responsibilities should not be viewed, defined and packaged according to their functional divisions (or departments). Instead, they must introduce process jobs and subsequently view, define and package the roles and responsibilities of their resources according to their business processes.

### **4. Process management and measurement systems**

Based on the dynamic nature of the business environments associated with organizations, adopting a process orientation cannot be seen as a single endeavor. Process-oriented organizations must introduce systems and practices through which they continuously define, understand, implement, execute, measure, analyze, improve and control their current business processes. This is necessary in order to ensure the continued relevance of their business processes as well as the sustainability of their process-oriented systems.

### **5. Process cultures**

Within the organizations that intend to adopt a process orientation, it is important to establish a culture that supports their business processes. This includes instilling a culture where all the relevant stakeholders value the significance of their business processes and are motivated to contribute to their success.

It is identified that Business Process Modelling can be used to support these concepts. In relation to a process perspective and process structure, organizations can use business process models to view and define themselves according to their business processes and their comprising elements. In relation to process jobs, organizations can use business process models to identify and define the roles and responsibilities of their resources according to their business processes. In relation to process management and measurement systems, organizations can use business process models to identify the measurement and management requirements regarding their business processes. In relation to a process culture, business process models can be used to show the relevant stakeholders why the organizations' business processes are important and how they can contribute to the success of these business processes.

#### **2.2.1.4.2. BUSINESS PROCESS MANAGEMENT LIFECYCLE AND BENEFITS**

The Business Process Management Lifecycle represent the methodical collection of actions (or phases) contained within the concept of Business Process Management. Business experts have produced variations concerning the way in which they package these actions [1, 8, 43, 44, 52, 54]. It is however noted that the overall range of actions that they include in their collections remains mostly similar. Through a review and consolidation of these varying collections, the following relevant actions related to the Business Process Management Lifecycle are identified:

##### **1. Design or Redesign of business processes**

The need to design or redesign business processes originates from organizations' need to achieve their objectives. With reference to the design of business processes, organizations intend to invent, define and document business processes that can enable them to achieve their newly-defined organizational objectives. With reference to the redesign of their business processes, organizations intend to refine, define and document their existing business processes in order to address the gaps between their actual performance and their predetermined targets. The redesign of these business processes is therefore aimed at ensuring that their actual performance is in accordance with their predetermined targets and that they eventually enable organizations to achieve their existing objectives.

##### **2. Implementation of business processes**

Upon completion of the design or redesign of their business processes, organizations must implement their business processes. This includes ensuring that the designed or redesigned business processes are standardized and rolled-out as their current procedures. This also includes ensuring that their resources and inputs are aligned with the requirements of these business processes.

##### **3. Execution of business processes**

The execution of business processes represents the actual completion of the implemented business processes of organizations. These business processes must be executed in accordance with the specifications that were identified and defined during their design or redesign.

##### **4. Measurement of business processes**

As part of the design or redesign of their business processes, organizations identify and define specific key performance indicators (KPI's) or process performance indicators (PPI's) that are related to their business processes. Based on these indicators, they measure the actual performance of their executed business processes.

## 5. Analysis of business processes

Upon completion of the measurement of their business processes, organizations analyze their business processes by comparing the actual performance of their executed business processes against specific predetermined targets.

## 6. Improvement of business processes

Upon completion of the analysis of their business processes, organizations aim to identify ways in which they can improve their business processes. These improvements must eventually address the variances between the actual performance of their business processes and their predetermined targets.

## 7. Control of business processes

The control (or management) of business processes represents the parent action (or phase) of the Business Process Management Lifecycle. Organizations control (or manage) their business processes by ensuring that they continuously and consistently design (or redesign), implement, execute, measure, analyze and improve their business processes. In this regard, the control (or management) of business processes do not represent a single action (or phase). Instead, it represents a collective and ongoing effort focused on the improvement and maintenance of business processes.

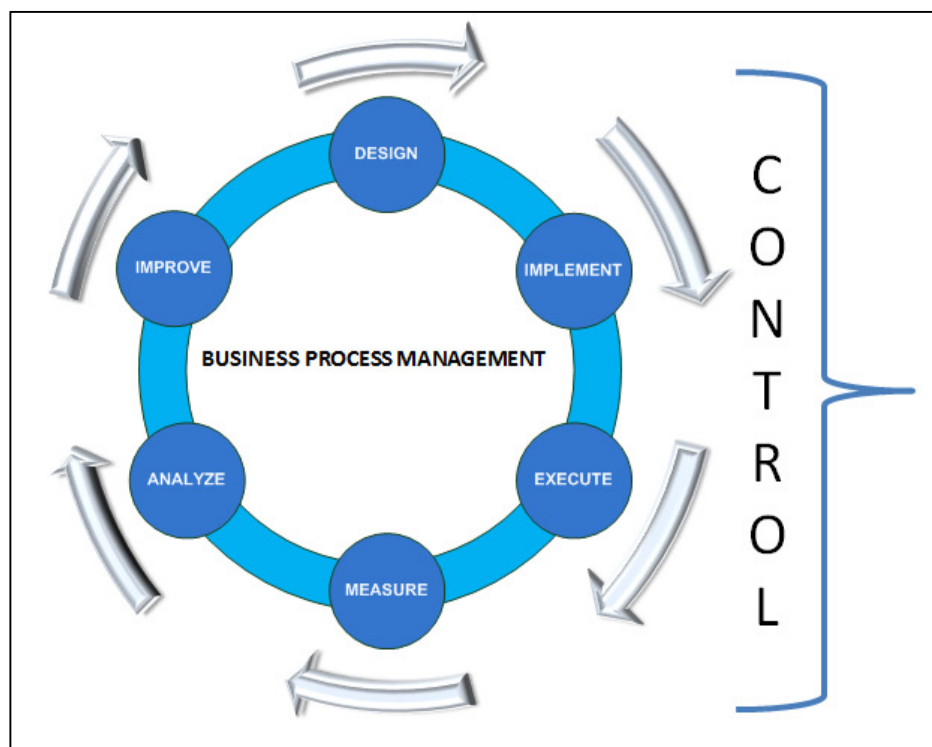


Diagram 10: Business Process Management – Lifecycle [Adapted from [1], [8], [43], [44], [51], [52], [54]]

Concerning the use of Business Process Management within organizations, Van den Bergh commented that “ the positive impact of Business Process Management has been clearly demonstrated ” [58].

The positive impact of Business Process Management is motivated by the benefits that can be gained through the proper execution of its included actions (or phases). These benefits are:

- **Drives the overall effectiveness, strategies and capabilities of organizations.**

Business Process Management includes the consistent design or redesign of business processes based on the objectives of their associated organizations. In this regard, Business Process Management can play an important role in ensuring that organizations can achieve their objectives and that they are enabled to drive their overall effectiveness, strategies and capabilities.

- **Define, document and understand business processes.**

Business Process Management includes defining and documenting the designed or redesigned business processes of organizations. By defining and documenting their business processes, organizations are enabled to properly understand their business processes. Ultimately, it is important for organizations to understand their business processes so that they can continuously improve and manage their business processes.

- **Effective performance measurement and structured analysis of business processes.**

Business Process Management includes the measurement of business processes and their subsequent analysis. Through the proper measurement and analysis of their business processes, organizations are enabled to eliminate wasteful activities from their business processes. Business Process Management can therefore assist organizations in the development and management of consistent, efficient and cost-effective business processes [Tregear, 59].

- **Improved customer service**

Business processes are executed to create value for their customers. Through the continuous improvement and management of their business processes, Business Process Management enables organizations to deliver improved value propositions to their customers [59].

Considering the above mentioned perspectives, Business Process Modelling can play an important role regarding the actions contained within the Business Process Management Lifecycle and eventually the performance and competitiveness of organizations. In relation to the design or redesign of their business processes, organizations can use Business Process Modelling to create business process models that visually define and document their business processes. These visual models subsequently enable

organizations to understand their business processes. In turn, organizations must understand their business processes in order to properly implement, execute, measure, analyze, improve and control their business processes. Through the proper design, implementation, execution, measurement, analysis, improvement and control of business processes, organizations are enabled to continuously improve and manage their business processes. Ultimately, this enables organizations to drive their effectiveness, strategies, efficiency and customer service.

### **2.2.1.5. DEFINITION OF BUSINESS PROCESS MODELLING AND BUSINESS PROCESS MODELS**

Business Process Modelling and business process models represent significant entities given the context of the research study. It is therefore appropriate to review and consolidate the definitions of these respective entities.

From a high-level perspective, Bandara described Business Process Modelling as “an approach for visually depicting how businesses conduct their operations” [60]. From a process-oriented perspective, Ellis defined Business Process Modelling as “the activity of visually representing the processes of an enterprise” [61]. With reference to the actions contained within the concept of Business Process Modelling, Accuprocess observed that it includes the “documentation of business processes using a combination of text and graphical notations” [10]. Glassey elaborated on its included actions and identified that it involves “methods and tools that support the capture, representation, organization and storage of knowledge on the state of an organization” [19]. Aligned with Glassey’s perspective, Harmon & Wolf described Business Process Modelling as “a technique to capture, organize and communicate information about business processes” [62].

The definition of a business process model is closely related to the definition of Business Process Modelling. Teplykh described a business process model as “all graphical representations of a business process; data, resources, and other related elements” [63]. Liu & Shen added that each business process model represents “an abstraction of an implemented process” [64]. Kress classified the possible states of this abstraction and described a business process model as “a representation of a current or proposed business process” [1]

Considering the above mentioned views, the following definitions are respectively formulated:

- *Business process models represent complete graphical depictions of either the current or proposed business processes of organizations.*

- *Business Process Modelling signifies an approach, which includes methods, tools and techniques that are used to visually capture, represent, organize, communicate and store the business processes of organizations.*

## 2.2.1.6. CHARACTERISTICS OF BUSINESS PROCESS MODELLING AND BUSINESS PROCESS MODELS

### 2.2.1.6.1. BUSINESS PROCESS MODEL REQUIREMENTS

Based on the efforts of Davids [65], specific requirements pertaining to business process models are identified. These requirements represent important considerations related to the design of business process models. They are:

- **Business process models should be designed and used for well-defined purposes.**

Probably the most important requirement associated with business process models is that they must be designed and used for well-defined purposes. It is fair to comment that without well-defined purposes, there is insufficient motivation for the design and use of business process models within organizations.

- **Business process models should serve as representations of reality.**

Business process models must be seen as the synchronization between two worlds; the modelling world and the modelled world [Mili et al., 66]. The graph below indicates the difference between the modelled world and the modelling world:

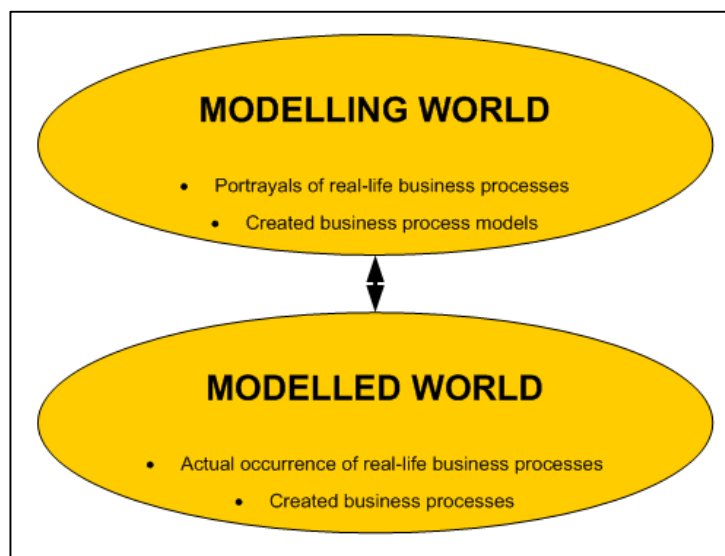


Diagram 11: Business Process Models - Modelling World and Modelled World [Adapted from [66]]

The modelling world includes the methods, techniques and tools that are used to design business process models, which subsequently serve as abstractions of the real-life activities contained within the modelled world. Business process models must therefore enable the synchronization of these two worlds by accurately portraying the real-life activities of their organizations. The design of business process models that are not realistic does not add value to organizations and are eventually not considered to be useful.

- **Business process models must be designed to show specific perspectives.**

Organizations expect to obtain specific process-related information from their business process models. Business process models must therefore be able to portray business processes from specific perspectives that are in accordance with the informational requirements of their associated organizations. Luo & Tung identified three prominent perspectives according to which organizations wish to view their business processes [67]. They are:

- **The object perspective**

The object perspective focuses on what is actually achieved by the business processes of organizations. Organizations that wish to view their business processes from an object perspective require business process models that illustrate the objects (i.e. raw materials, data) contained within their business processes as well as the transformations that occur with regard to these objects (i.e. raw materials are transformed to final products, data is refined to usable information).

- **The activity perspective**

The activity perspective focuses on how things are achieved by the business processes of organizations. Organizations that wish to view their business processes from an activity perspective require business process models that indicate the activities executed within their business processes as well as the relationships that exist among these activities [Ying et al, 68].

- **The role perspective**

The role perspective focuses on the roles within the business processes of organizations. Organizations that wish to view their business processes from a role perspective require business process models that illustrate the entities responsible for the execution of the actions within their business processes.

- **Designed to a certain scale or level of detail**

Business process models must be designed to include the required level of detail, which is determined based on the informational requirements of their associated organizations. This required level of detail can range from basic representations of business processes to very elaborate, sophisticated and detailed representations of business processes. Glassey identified three common levels of detail relevant to business process models [19]. They are:

- **Abstract Level**

Business process models that are related to an abstract level of detail are strategically-focused and portray high-level business processes. These business process models portray the links between the high-level business processes and objectives of organizations. Ultimately, they represent business process models of a low level of detail and complexity.

- **Organizational Level**

Business process models that are related to an organizational level of detail are structurally-focused and portray business processes within the context of the frameworks of their associated organizations. Ultimately, they represent business process models that are of a higher level of detail and complexity than those associated with the abstract level.

- **Operational Level**

Business process models that are related to an operational level of detail are action-focused and portray the operational business processes of organizations. This includes the portrayal of the activities necessary to create the operational outputs of organizations. Ultimately, they represent business process models that are of a higher level of detail and complexity than those associated with the organizational level.

The graph below indicates these three levels of detail and their subsequent impact on the complexity of business process models:



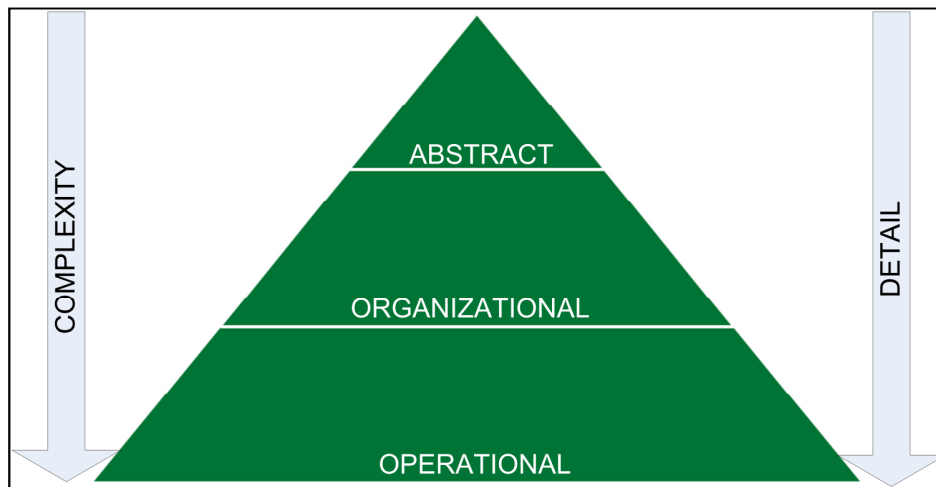


Diagram 12: Business Process Models - Levels of Detail [19]

#### 2.2.1.6.2. PURPOSES OF BUSINESS PROCESS MODELS

It has been mentioned that business process models must be designed and used for well-defined purposes. In relation to this perspective, business process models can be designed and used for various purposes. These purposes can be related to certain isolated initiatives within organizations. They may also be related to the management of organizations' business processes. The following prominent purposes associated with the design and use of business process models are identified:

- **Defining, documenting and communicating business processes**

Inevitably, organizations must define and document their business processes [Vaziri & De Oliveira, 69]. This is required in order to enable them to effectively understand and communicate their business processes. Organizations can define and document their business processes through the use of Business Process Modelling, which involves the design of business process models that visually portray their business processes. The design and use of business process models to define and document business processes represent their primary purpose. In turn, the design and use of business process models for this purpose represents a prerequisite with regard to their use for other purposes.

- **Information and knowledge management within organizations**

Organizations are recognizing that gaining a competitive advantage and being innovative depends more and more on what they know and not entirely on what they own [Wolfaardt, 70]. In relation to this recognition, information and knowledge are increasingly accepted as key assets of organizations [Kalpic & Bernus, 71] and represent "power in all endeavors" [Tsai, 72].

According to Kalpic & Bernus, “it is a well-known fact that much of the existing information and knowledge, which is extremely valuable to an enterprise, is not always made explicit or formalized. The information and knowledge might not be available for use by the organization and is sometimes even permanently lost for the enterprise” [71]. This introduces the view that in order to ensure the availability, sustainability and effective use of their information and knowledge, organizations must properly generate, document, share and store their information and knowledge. This view is also relevant to the information and knowledge regarding their business processes.

Business process models can be designed and used to create and store information and knowledge regarding business process [Koubarakis & Plexousakis, 73]. In addition, business process models can be designed and used to ensure that information and knowledge regarding business processes is readily available and usable [Grosskopf et al., 74]. In this regard, business process models can play a significant role with regard to the management of process-related information and knowledge within organizations.

- **Analysis and improvement of business processes**

Organizations that wish to remain competitive and sustainable must continuously analyze and improve their business processes. According to Jacka & Keller, “processes must be analyzed to ensure they support key business objectives. Process analysis is particularly useful in ensuring the accomplishment of business objectives relating to customer services, efficiency, effectiveness and profitability” [75].

In order to properly analyze and improve their business processes, organizations must first define, document and understand their “as-is” business processes. Business process models can be designed and subsequently used to meet this demand [Xinming & Haikun, 76]. The design and use of business process models surpasses the basic ability to define and document business processes. The created business process models can also visually portray process features such as inter-functional communication, resource requirements and sequential constraints. Through the visual portrayal of these types of features, business process models can provide additional support to organizations during the analysis and improvement of their business processes.

- **Development of information systems**

Bentellis & Boufaida stated that “the objectives of an organization are achieved by implementing enterprise processes that are supported by the enterprise’s information systems” [77]. Based on this statement, it is recognized that the information systems of organizations must be able to support their business processes. In order to accomplish this, organizations must determine the requirements of their

information systems based on the requirements of their business processes. Business process models can be designed to visually portray business processes and subsequently allow organizations to analyze their information system requirements.

- **Business Process Management**

The Business Process Management Lifecycle was discussed during a previous section. It was mentioned that Business Process Modelling can play a significant role during the execution of the actions (or phases) contained within this lifecycle. In relation to the design or redesign of their business processes, organizations can use Business Process Modelling to create business process models that visually define and document their business processes. These visual models subsequently enable organizations to understand their business processes. In turn, organizations must understand their business processes in order to properly implement, execute, measure, analyze, improve and control their business processes. Through the proper design, implementation, execution, measurement, analysis, improvement and control of business processes, organizations are enabled to continuously improve and manage their business processes.

- **Other purposes**

The aforementioned purposes represent the most prominent purposes associated with the design and use of business process models. Based on the work of Kress [1] and Eriksson [78] as well as personal experience, some other purposes associated with the design and use of business process models are identified. These purposes are:

- **Total Quality Management (TQM)**

Organizations that adopt a Total Quality Management system intend to manage the quality of their business processes as a sub-component of this system. Organizations can design and use business process models to support the management of their business processes. In this regard, business process models can be designed and used to support the quality of their business processes within the broader context of their Total Quality Management systems.

- **Activity-Based Costing**

Organizations that execute Activity-Based Costing wish to identify the costs associated with their activities. Business process models can be designed to visually portray the activities included within the business processes of organizations. In this regard, business process models can provide organizations with vital inputs during the execution of their Activity-Based Costing efforts.

- **Six Sigma Projects**

Six Sigma Projects are associated with a focus on process capabilities. In turn, organizations intend to define, measure, analyze and improve their business processes in order to improve the capabilities of their business processes. Organizations can design and use business process models to support the management of their business processes. In this regard, business process models can support the improvement of organizations' process capabilities, which is an essential part of Six Sigma Projects.

- **Automation Efforts**

Through an analysis of their business processes, organizations can identify repetitive and tedious activities or tasks that can be automated. Business process models can be designed and used to support the analysis of organizations' business processes. In this regard, business process models can be designed and used to support the automation efforts of organizations.

- **Compliance and Accreditation**

It is identified that in order to comply with certain standards or to achieve certain accreditations, organizations must formally define and document their business processes. In turn, they can be audited based on their adherence to these defined and documented business processes (e.g. the specifications of the International Organization for Standardization (ISO) 9001). Organizations can design and use business process models to formally define and document their business processes. In addition, business process models can provide organizations with visual portrayals concerning the business processes that they must execute. In this regard, organizations can design and use business process models to support their compliance with certain standards and their ability to achieve certain accreditations.

- **Customer Relationship Management**

Organizations can design and use business process models to analyze whether the outputs of their business process are synchronized with the expectations of their customers. In the case where there are gaps between the outputs of their business processes and the expectations of their customers, they can address these gaps and subsequently improve their ability to satisfy the needs of their customers. In this regard, business process models can be designed and used to support the relationships between organizations and their customers.

- **Benchmarking**

Organizations can design and use business process models to measure and analyze how their business processes and their subsequent outcomes compare to those of industry leaders or organizations that

are considered superior with regard to the management of their business processes. In this regard, business process models can be designed and used to support the continuous improvement of organizations' business processes.

#### **2.2.1.7. DEFINITION OF BUSINESS PROCESS MODELLING METHODOLOGIES,-TECHNIQUES AND -TOOLS**

Based on the reviewed literature, it is identified that the definitions related to Business Process Modelling Methodologies, - Techniques and –Tools are sometimes used in an interchangeable and ambiguous manner. This is done albeit they possess different fundamental meanings. It is therefore considered appropriate to identify clear definitions for these distinct concepts:

- ***Business Process Modelling Methodologies*** *comprise of methods, approaches, frameworks, concepts and guidelines that are applied to guide the execution of the process modelling lifecycle.*
- ***Business Process Modelling Techniques*** *comprise of depiction conventions, notations, languages and grammars that are applied to generate the illustration features and content of business process models.*
- ***Business Process Modelling Tools*** *comprise of software-based resources that are applied to support the execution of the process modelling lifecycle.*

#### **2.2.1.8. CHARACTERISTICS OF BUSINESS PROCESS MODELLING METHODOLOGIES –FRAMEWORK FOR EXECUTION**

There is a set of general actions associated with the application of Business Process Modelling. This set of actions represents a roadmap for the design of the business process models that are required by organizations. Based on the work of Gourishankar [34], Bandara [60] and Jacka & Keller [75], the actions contained within this set are identified. They are:

- 1. Define the purposes of the modelling application**
- 2. Gather information and identify the relevant business processes**
- 3. Design the required business process models**

As mentioned earlier, the application of Business Process Modelling should be motivated by well-defined purposes. It is important to define these purposes in order to identify and understand the requirements related to the specific modelling application and the eventual business processes models.

Based on these requirements, the required information is gathered and the relevant business processes are identified. This activity represents an iterative process whereby information is continuously gathered, used, reviewed and refined until the relevant business processes are sufficiently verified, elaborated and defined.

The necessary information is gathered and the relevant business processes are identified by:

- A. Observing occurrences of the relevant business processes.
- B. Interviewing the participants associated with the relevant business processes e.g. managers, process owners and staff responsible for the execution of the relevant business processes.
- C. Reviewing business correspondence, reports, statements, policies, strategies and regulations of the associated organizations.

Based on the gathered information and the identified business processes, the required business process models are designed. This activity represents an iterative process whereby the information portrayed by the designed business process models are continuously reviewed, used and refined until it is sufficiently verified, elaborated and portrayed.

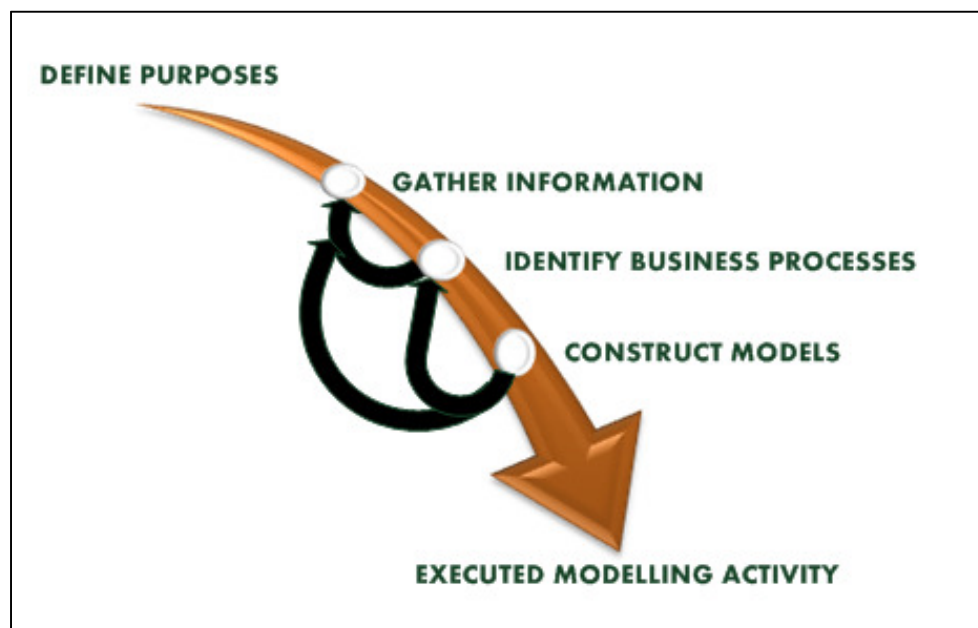


Diagram 13: Business Process Modelling - Modelling Framework

### 2.2.1.9. BUSINESS PROCESS MODELLING TECHNIQUES –QUALITY CHARACTERISTICS

The suitability of Business Process Modelling Techniques for specific modelling applications is evaluated based on the quality characteristics related to their depiction languages and their subsequent abilities to address the requirements of the specific modelling applications. The more prominent characteristics associated with such evaluations are:

- **Accuracy** [Kock et al., 79]

*Accuracy represents the ability of a Business Process Modelling Technique to design business process models that can convey the business processes of an organization in an accurate and truthful way.*

- **Completeness** [47]

*Completeness is the ability of a Business Process Modelling Technique to design business process models that can convey all the relevant business process information required by an organization.*

- **Complexity** [Sedera et al., 80]

*Complexity is the degree to which a Business Process Modelling Technique designs business process models that are difficult to design, understand and use.*

- **Ease of generation** [79]

*Ease of generation is the degree of ease associated with the design of business process models using a specific Business Process Modelling Technique.*

- **Ease of understanding** [Recker & Mendling, 81]

*Ease of understanding is the extent to which a Business Process Modelling Technique is able to design business process models that are easy to understand.*

- **Ease of use** [67]

*Ease of use is the ability of a Business Process Modelling Technique to design business process models that are easy to use.*

- **Economy** [Luttighuis et al., 82]

*Economy is the degree to which a Business Process Modelling Technique can design business process models that depict all the relevant business process information while using the minimum possible graphical notations.*

- **Effectiveness** [68]

*Effectiveness is the degree to which a Business Process Modelling Technique can design business process models that enables an organization to achieve its modelling objectives.*

- **Efficiency** [68]

*Efficiency is the capability of a Business Process Modelling Technique to design business process models by using the minimum possible amount of resources.*

- **Expressiveness** [68]

*Expressiveness is the degree to which a Business Process Modelling Technique is capable of designing business process models for any number and type of applications.*

- **Flexibility** [68]

*Flexibility is the ability of a Business Process Modelling Technique to design business process models that are easy to adapt in response to occurring business process changes.*

- **Formality** [Lu & Sadiq, 83]

*Formality is the ability of a Business Process Modelling Technique to design business process models that contain appropriate notations and conventions in aid of the differentiated illustration of all relevant business process elements.*

- **Software support** [33]

*Software support refers to the level of software support that can be offered to a Business Process Modelling Technique during the design or subsequent use of its associate business process models.*

- **Suitability** [68]

*Suitability is the capability of a Business Process Modelling Technique to design business process models that are considered appropriate for a specific application.*

It is noted that these quality characteristics are often evaluated in an isolated, uncoordinated, inconsistent and unclear manner. In relation to this, there are insufficient proposals concerning an approach to execute these evaluations. It is further recognized that there is a lack of formal measures to properly quantify the impact that these quality characteristics have on the abilities of their related techniques. This causes this subject to remain a poorly researched field [Hommes & Reijswoud, 84]. Given these deficiencies, it becomes difficult to evaluate the suitability of the techniques that are



considered for a specific modelling application. The need therefore exists to further analyze, dissect, arrange and refine these quality characteristics. This is required in order to ultimately develop a formal measurement framework that can be used to evaluate the suitability of Business Process Modelling Techniques for specific modelling applications. This need is addressed in a later chapter of this document.

## **2.2.2. BUSINESS PROCESS MODELLING TECHNIQUES**

Given the scope and time-limit of the research study, the aim of this section is solely to provide brief summaries regarding the relevant Business Process Modelling Techniques. These summaries are considered sufficient for the purposes of the research study.

### **2.2.2.1. BUSINESS PROCESS MODELLING NOTATION (BPMN)**

#### **2.2.2.1.1. INTRODUCTION**

Business Process Modelling Notation (BPMN) represents a recent [33] and popular [Koskela & Haajanen, 85] addition to the large group of available Business Process Modelling Techniques. The first version of BPMN was developed by the Business Process Management Initiative and was released in 2004 [Devillers, 86]. Since then it has been adopted, ratified, consolidated and standardized by the Object Management Group [Indulska et al., 87]. According to Devillers, “as of 2011, Business Process Modelling Notation is the most used notation for the modelling of business processes and is considered the de facto standard” [86].

BPMN is based on an “amalgamation of all best practices within the business modelling community” [Object Management Group, 88] and denotes an evaluation and extension of previously developed techniques [Object Management Group, 89]. These previously developed techniques include (among many) the Unified Modelling Languages (UML), Integration Definition Methods (IDEF) and Event-Driven Process Chains (EPC's) [88].

#### **2.2.2.1.2. PURPOSE**

BPMN intends to address the needs of all the stakeholders that are associated with the modelling of organizations' business processes. It intends to do this by providing them with a technique that they can use to model, document, understand and communicate business processes in a standard, effective and flexible manner [10, 33, 88]. Ultimately, this is enabled by the elements of BPMN.

### 2.2.2.1.3. ELEMENTS

BPMN embodies the use of a Business Process Diagram (BPD) to create graphical models of the business processes of organizations [88]. This Business Process Diagram comprises of graphical elements that are considered to be well-defined, fully differentiated, familiar and all-encompassing modelling shapes.

There are two sets of elements relevant to the Business Process Diagram. Both of these sets are important, because they enable designers to select and customize the levels of detail of their business process models. These sets are [Muehlen et al., 90]:

- **Full set**

The full set comprises of all the elements that are defined for this technique (for an investigation into the full set refer to [88]). This set enables the expressive power and flexibility necessary to model more advanced and complex business processes. In addition, it enables the use of BPMN for various modelling applications.

- **Core set**

The core set comprises of basic elements that are used to create basic business process models. These basic elements are considered as easy to use and easy to understand. It is noted that additional elements can be incorporated into this set [88]. These elements can be added without surrendering the basic depiction properties of the overall set. The core set is separated into five categories of elements. These categories and their included elements are the following [88]:

#### 1. Flow Objects

##### a. Events

Events are occurrences that generate the need for specific actions to be executed (trigger events) or describe the related impacts of the executed activities (result events). These trigger events or result events affect the subsequent flow of business processes.

##### b. Activities

Activities describe the actions that must be executed within business processes as stipulated by their associated definitions. These activities are caused by trigger events or result events.

##### c. Gateways

Gateways are elements of control that indicate the joining and splitting of sequence flows. It is worth mentioning that the core set of elements does not include any distinguishing semantics related to the

various possible gateways. This implies that for the use of any semantics related to gateways, it is necessary to consider the elements and semantics that are contained within the full set.

## **2. Data**

### **a. Data Objects, -Inputs and -Outputs**

Data objects indicate the data objects that are required by activities or the data objects that are generated by activities. Data Inputs indicate the data objects that are required by business processes and Data Outputs indicate the data objects that are generated by business processes.

## **3. Connecting Objects**

### **a. Sequence Flows**

Sequence flows indicate the sequences according to which the activities and tasks within business processes are executed.

### **b. Message Flows**

Message flows indicate the exchange of messages between the participants within business processes.

### **c. Associations**

Associations indicate the link of information and artifacts with the other graphical elements within business processes.

## **4. Swimlanes**

### **a. Pools**

Pools are used as partitioning devices to indicate the grouping of specific activities according to the participants responsible for their execution.

### **b. Lanes**

Lanes indicate sub-partitioning within business processes and sometimes even pools. These lanes are used to categorize and organize activities within business processes.

## **5. Artifacts**

### **a. Groups**










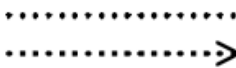
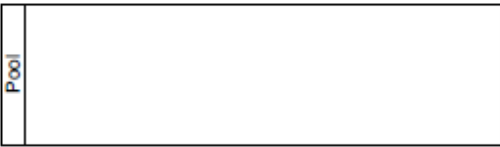
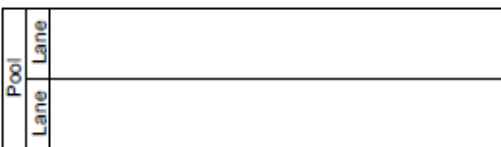

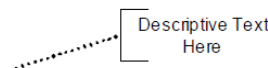
Groups represent the grouping of activities within the same categories (as categorized by lanes).

### **b. Text Annotations**

Text annotations represent additional textual information that designers want to communicate to the users.

The table below depicts the symbols specified for each of the elements within the core set:

Table 1: BPMN - Core Set of Elements [88]

<b>EVENTS</b>	
<b>ACTIVITIES</b>	
<b>GATEWAYS</b>	
<b>DATA OBJECTS, -INPUTS, -OUTPUTS</b>	 <i>Collection</i>  Data Input    Data Output  
<b>SEQUENCE FLOWS</b>	
<b>MESSAGE FLOWS</b>	
<b>ASSOCIATIONS</b>	
<b>POOLS</b>	
<b>LANES</b>	
<b>GROUPS</b>	
<b>TEXT ANNOTATIONS</b>	

The diagram below illustrates an example regarding the use of the core set of elements of BPMN:

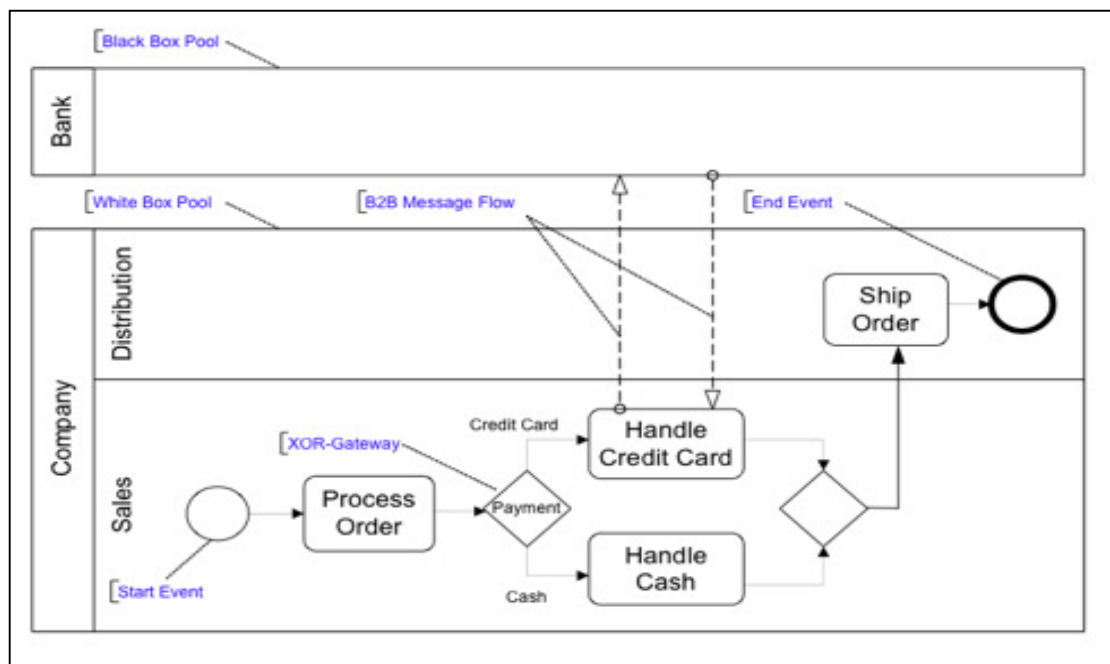


Diagram 14: BPMN - Model Example [Schnieders et al., 91]

#### 2.2.2.1.4. ADVANTAGES AND DISADVANTAGES

There are significant advantages associated with the use of BPMN. Through its amalgamation of many of the best practices within the modelling community, BPMN has evolved into a consolidated and standard technique that is easy to understand [33] and that can be used by the broadest range of audiences [Flowers & Edeki, 92]. BPMN possesses a rich range of formal semantics that empowers organizations to model both basic and complex business processes. In addition, this rich range of semantics enables the use of BPMN for various different modelling applications. It is however noted that BPMN was specifically developed for process-related purposes and cannot be used for non-process purposes i.e. the modelling of organizational structures and data models [Modeliosoft, 93]. This can be considered a potential weakness of BPMN.

#### 2.2.2.2. EVENT-DRIVEN PROCESS CHAINS (EPC'S)

##### 2.2.2.2.1. INTRODUCTION

Event-Driven Process Chains (EPC's) represents one of the more traditional techniques used to model the business processes of organizations [Loos & Fettke, 94]. This technique forms part of the

Architecture of Integrated Information Systems Framework (ARIS Framework), which represents a broader technique for the modelling of organizations [Scheer, 95]. It was developed through a collaborative effort between researchers at the Institute for Information Systems of the University of Saarland and SAG AG [Keller et al., 96]. Currently, EPC's is one of the most popular techniques used to model the business processes of organizations [86]. In addition, it is supported and ratified by SAP and other major software vendors [66].

#### **2.2.2.2.2. PURPOSE**

According to Loos & Fettke, "Event-Driven Process Chains is often used for capturing and discussing business processes with people who have never trained in any kind of modelling technique" [94].

In relation to this comment, the purpose of EPC's is to provide organizations with a technique that is easy to understand and that can be used by all their stakeholders [47, 86].

#### **2.2.2.2.3. ELEMENTS**

EPC's signifies a technique that is used to describe the relationships between the functions and events in organizations [Dijkman et al., 97]. It does this by graphically depicting the way in which events and functions exist and alternate within the business processes of organizations [Gruhn & Laue, 98].

In order to do this, it uses four basic elements [98]. These elements are:

##### **1. Events**

Events are the occurrences within business processes that signify the triggers of functions or exist as the results of executed functions. Business processes that are depicted through the use of EPC's are characterized by always starting and ending with events [63, 86].

##### **2. Functions**

Functions describe the activities or tasks that have to be performed as stipulated by their associated business process definitions.

##### **3. Logical Operators**

Logical operators indicate the logical relationships and dependencies between the functions and events contained within business processes [Soderstrom et al., 99]. These logical operators serve as decision points for determining the progression flow within business processes. The most common logical operators are [97]:

**a. AND (denoted  $\wedge$ )**

In the case where this logical operator is placed prior to a function, it specifies the requirement for all inflowing (pre-condition) events to occur in order for the relevant function to commence.

In the case where this logical operator succeeds a relevant function, it specifies that all the subsequent flow paths (post-conditions) are followed.

**b. OR (denoted OR)**

In the case where this logical operator is placed prior to a function, it specifies the requirement for one or more of the various inflowing (pre-condition) events to occur in order for the relevant function to commence. In the case where this logical operator succeeds a relevant function, it specifies that one or more of the subsequent flow paths (post-conditions) can be followed.

**c. XOR (denoted  $\times$ )**

It is important to note that this logical operator is not placed prior to functions given its exclusive event-function relationship. In the case where this logical operator succeeds a function, it specifies that only one of the subsequent flow paths (post-conditions) can be followed.

The graph below illustrates the general concepts of these logical operators:

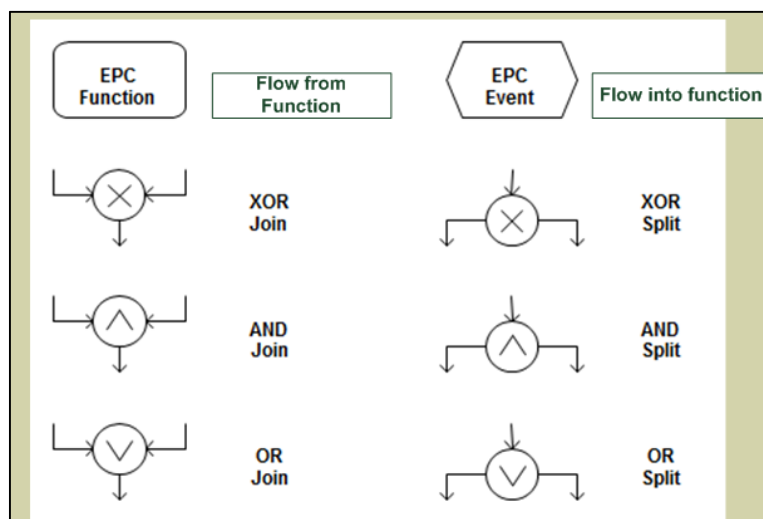


Diagram 15: EPC's - Logical Operators [Mendling, 100]

**4. Control Flows**

Control flows indicate the progression flows within business processes.

Above and beyond these basic elements, Event-Driven Process Chains can also incorporate several other elements within the basic model constructs. The most common of these additional elements are:

- **Organizational Units**

Organizational units convey the entities responsible for the execution of functions within business processes [94].

- **Data Flows and Data Objects**

Data flows indicate the relationships between functions and particular data objects i.e. organizational documents, databases, application systems.

- **Other Resources**

Other resources may include specific knowledge, human competencies, physical materials, equipment, and machinery [94]. It is noted that only a few formal semantics are attributed to these elements and their formalization [86]. This has resulted in a variation in the way designers depict these elements in their business process models.

The diagram below depicts the symbols used to convey the basic elements of EPC's. It also depicts some of the symbols used to convey some of the additional elements (for an investigation into the symbols relevant to "Other Resources" refer to [94]):

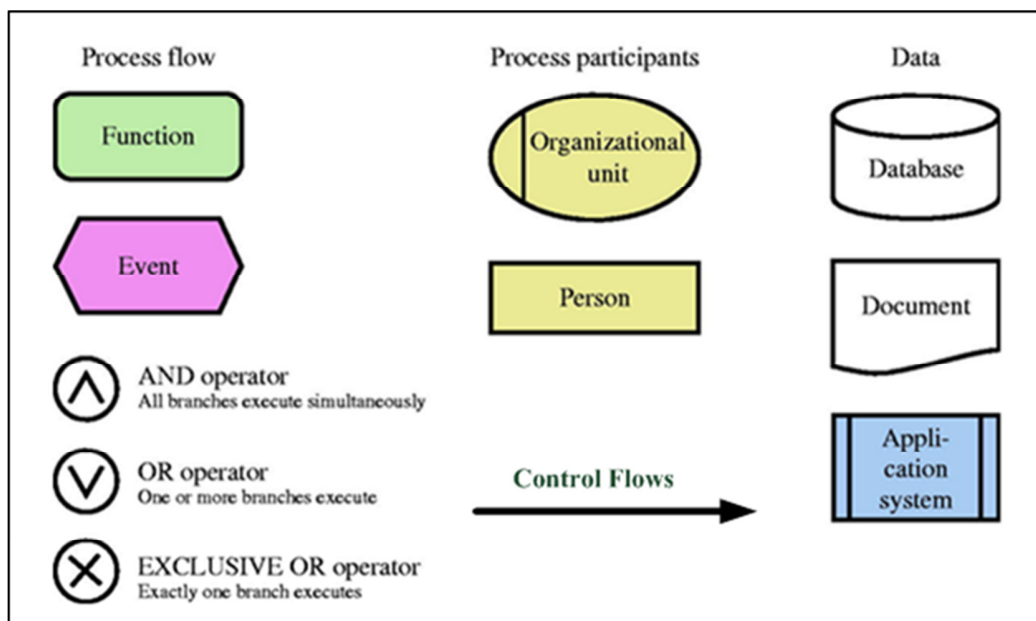


Diagram 16: EPC's - Basic Set of Elements [Gersch et al., 101]

The diagram below conveys an example of the use of EPC's:



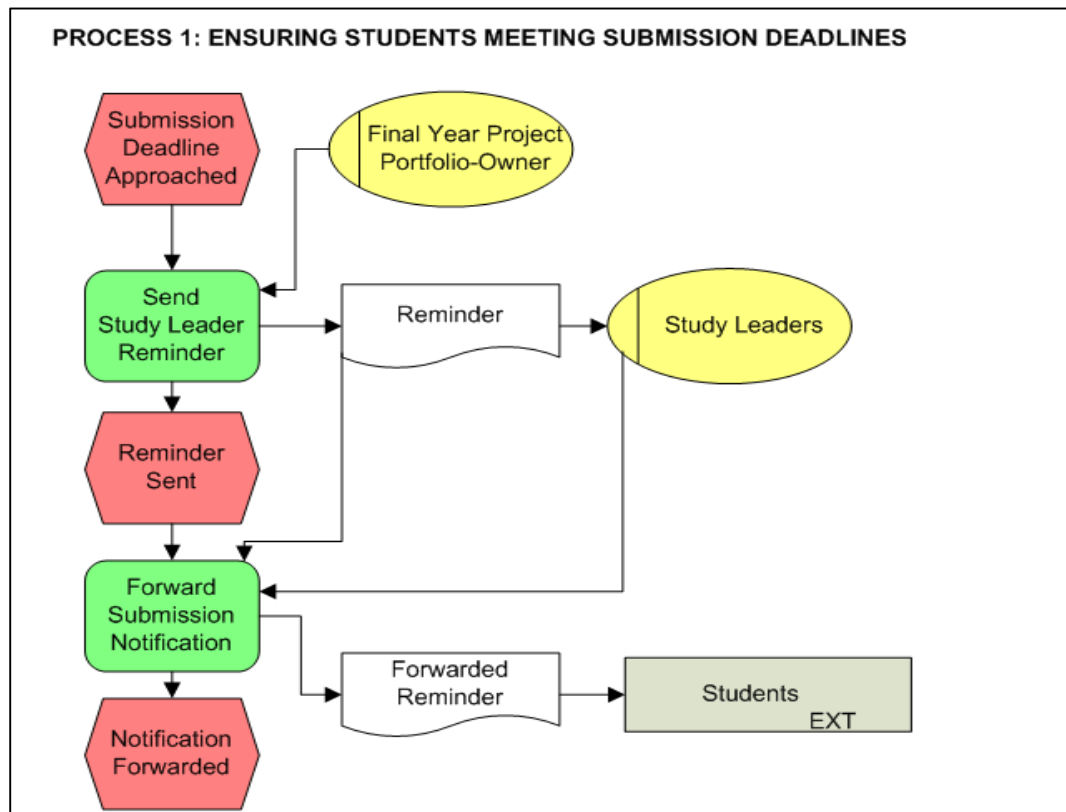


Diagram 17: EPC's - Model Example

#### 2.2.2.2.4. ADVANTAGES AND DISADVANTAGES

The promoted strength of EPC's is its simplicity, flexibility and the ease with which it can be understood and used [Tsai et al., 102]. In addition, it is supported and ratified by SAP and other major software vendors. These characteristics make it a widely acceptable and popular technique to model the business processes of organizations. Although the semantics of its basic set of elements are well-defined, there is still a lack of formalization associated with the semantics of its additional elements. This can limit its use to clearly depict some of the elements of more detailed business processes. This can be considered a weakness of EPC's.

#### 2.2.2.3. INTEGRATED MODELLING DEFINITION METHODS (IDEF)

Integrated Modelling Definition Methods (IDEF) is a family of methods originating from the US Air Force's Integrated Computer-Aided Manufacturing (ICAM) Program [66]. Within this family, the Integrated Definition Method 0 (IDEF0) and Integrated Definition Method 3 (IDEF3) are identified as the two respective techniques that are used to model business processes [86].

### **2.2.2.3.1. INTEGRATED DEFINITION METHODS (IDEF) – IDEF0**

#### **2.2.2.3.1.1. INTRODUCTION**

The Integrated Modelling Definition Method 0 (IDEF0) represents a function modelling technique that is used to create structured and graphical representations of business systems. This technique includes rules, guidelines and semantics that enable the modelling of system functions, functional relationships and data in support of systems integration [FIPS PUBS, 103].

#### **2.2.2.3.1.2. PURPOSE**

The purpose of IDEF0 is to provide organizations with a modelling technique that is generic, conceptual, rigorous and concise [103]. In addition, it intends to enable the evaluation of business systems of different scopes and complexities.

#### **2.2.2.3.1.3. ELEMENTS**

This technique uses certain basic elements to design graphical and structured representations of business systems. These elements are [103]:

##### **1. Functions (Boxes)**

Functions indicate the actions that must be completed as part of the functional system.

##### **2. Flows (Arrows)**

Flows indicate the progression flow between the activities within the functional system.

##### **3. Inputs**

Inputs indicate elements that are consumed by functions in order to create outputs. Inputs are linked to arrows always entering functions from the left.

##### **4. Controls**

Controls indicate certain conditions that are linked to the execution of functions and that must be adhered to in order to create the correct outputs. Controls are linked to arrows always entering functions from above.

##### **5. Outputs**

Outputs indicate the created products of executed functions. Outputs are linked to arrows leaving functions on their right.

##### **6. Mechanisms**

Mechanisms are linked to arrows leaving or entering functions from below bottom.

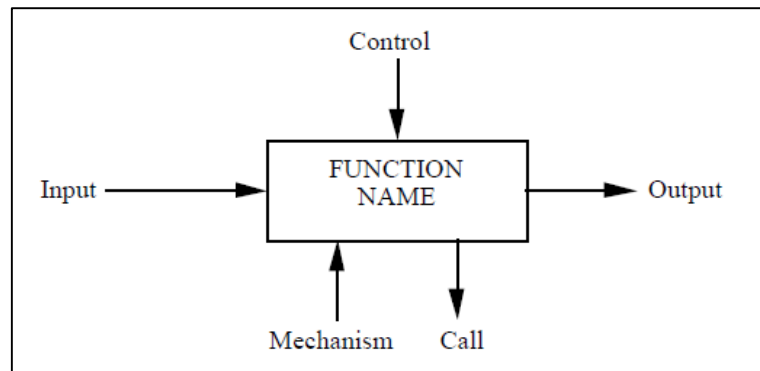
**a. Mechanisms leaving functions**

Indicate additional information required in support of the execution of functions.

**b. Mechanisms entering functions (also known as Calls)**

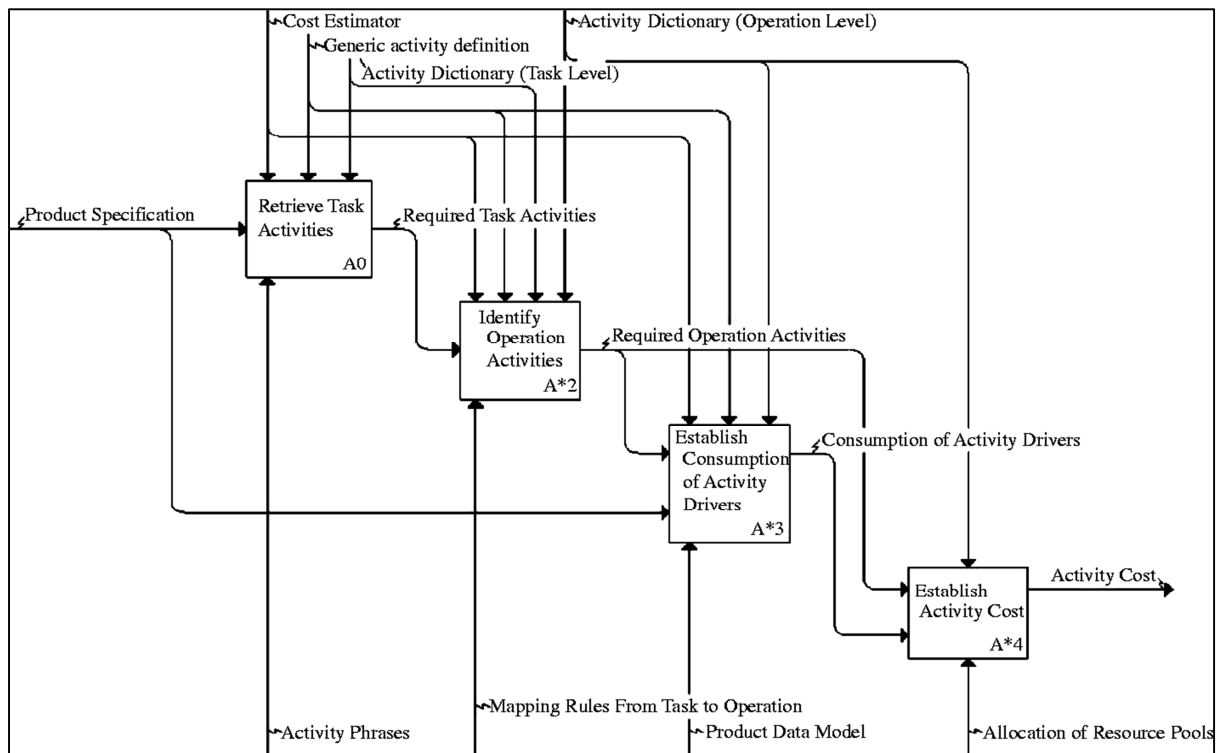
Indicate the sharing of detail between models or between portions of the same models.

The graph below illustrates the basic elements of IDEF0:



**Diagram 18: IDEF0 - Basic Set of Elements [103]**

The diagram below depicts an example regarding the use of IDEF0 to model business processes:



**Diagram 19: IDEF0 - Model Example [Chen & Wang, 104]**

#### **2.2.2.3.1.4. ADVANTAGES AND DISADVANTAGES**

The strength of IDEF0 is that it is easy to learn, which is based on the fact that it only uses a few basic elements to model business processes [Bosilj-Vuksic et al., 105]. Its formal and rigorous nature also provides organizations with a way to model their business processes in a standard manner. There is however significant disadvantages associated with the use of IDEF0. Firstly, one of the rules of this technique is that each model should consist of 3 to 6 functions [103]. This rule subsequently constrains the flexibility with which organizations can model their business processes and the level of detail that can be conveyed by their business process models. It also limits the adaptability of the models when changes to their associated business processes may occur. Secondly, IDEF0 does not allow for the natural representation of timing, sequencing and decision logic, which causes certain modelling anomalies and makes it difficult for users not familiar with the technique to understand [KBSI, 106].

#### **2.2.2.3.2. INTEGRATED DEFINITION METHODS (IDEF) – IDEF3**

##### **2.2.2.3.2.1. INTRODUCTION**

The Integrated Definition Method 3 (IDEF3) is a technique that is used to capture process descriptions and to model the sequences of systems [47]. It includes a structured approach and proven guidelines to model these sequences and captures the necessary process-related information through the use of scenarios as the units of operation [31].

##### **2.2.2.3.2.2. PURPOSE**

The purpose of IDEF3 is to provide a modelling technique that is easy to understand and use while offering consistent and reliable practices [Mayer et al., 107]. In addition, it intends to support the modelling of process information from multiple levels of abstraction [107].

##### **2.2.2.3.2.3. ELEMENTS**

IDEF3 uses a set of basic elements to capture, organize and illustrate process-related information. The elements contained in this set are [107]:

##### **1. Units of behaviour (UOB's)**

Units of behaviour represent the types of situations that occur within business processes.

##### **2. Links**

Links represent connectors that are used to convey relationships between the various units of behaviour within business processes. The three most notable links are:

#### a. Simple precedence links

Simple precedence links convey basic temporal precedence from one unit to another.

#### b. Constraint precedence links

Constraint precedence links convey constraints that are placed on the progression flow of business processes, which is determined based on the relationships between the various units of behaviours.

#### c. Relational links

Relational links convey the existence of possible constraints-based relationships between units of behaviour, but are not formally defined and serve mostly as user-based links.

### 3. Junctions

Junctions convey the divergence or convergence of flows within business processes. The five general junctions specified for IDEF3 are [107]:

#### a. AND junctions and AND synchronized junctions

In the case where the AND junction is placed prior to a specific unit of behaviour, it indicates that all preceding units of behaviour flowing into the junction must be completed as prerequisites for the subsequent activation of the specified unit of behaviour. The theory for AND synchronized junctions are the same, with the difference being that all prerequisite units of behaviour must be completed simultaneously.

In the case where the AND junction is placed after a specific unit of behaviour, it indicates that all succeeding units of behaviour linked to the junction are activated. The theory for AND synchronized junctions are the same, with the difference being that all succeeding units of behaviour must start simultaneously.

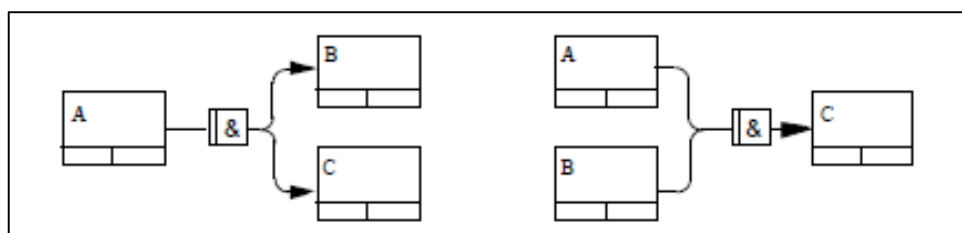


Diagram 20: IDEF3 - AND Junctions [107]

#### b. OR junctions and OR synchronized junctions

In the case where the OR junction is placed prior to a specific unit of behaviour, it indicates that at least one of the preceding units of behaviour flowing into the junction must be completed as a prerequisite

for the subsequent activation of the specified unit of behaviour. The theory for OR synchronized junctions are the same, with the difference being that the activated prerequisite units of behaviour must be completed simultaneously.

In the case where the OR junction is placed after a specific unit of behaviour, it indicates that all succeeding units of behaviour linked to the junction are activated. The theory for OR synchronized junctions are the same, with the difference being that the activated and succeeding units of behaviour must start simultaneously.

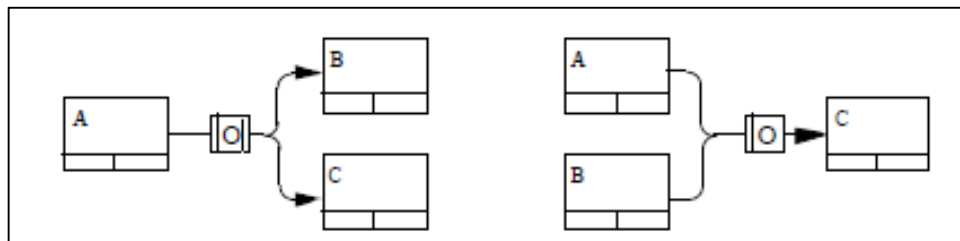


Diagram 21: IDEF - OR Junctions [107]

### c. XOR junction

It is important to note that the XOR is not placed prior to a specific unit of behaviour given its exclusive relationship with one preceding unit of behaviour. In the case where the XOR junction succeeds a specific unit of behaviour, it implies that only one of the possible downstream units of behaviour can be activated.

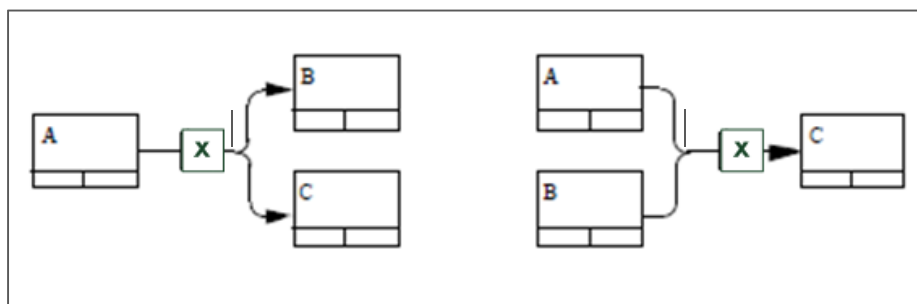


Diagram 22: IDEF - XOR Junctions [107]

## 4. Referents and Notes

Referents and notes can be used to enhance descriptions. It can serve as a means to incorporate additional meaning or to describe the relationships between the units of behaviour contained within business processes.

The graph below illustrates the symbols associated with the basic elements of IDEF3:

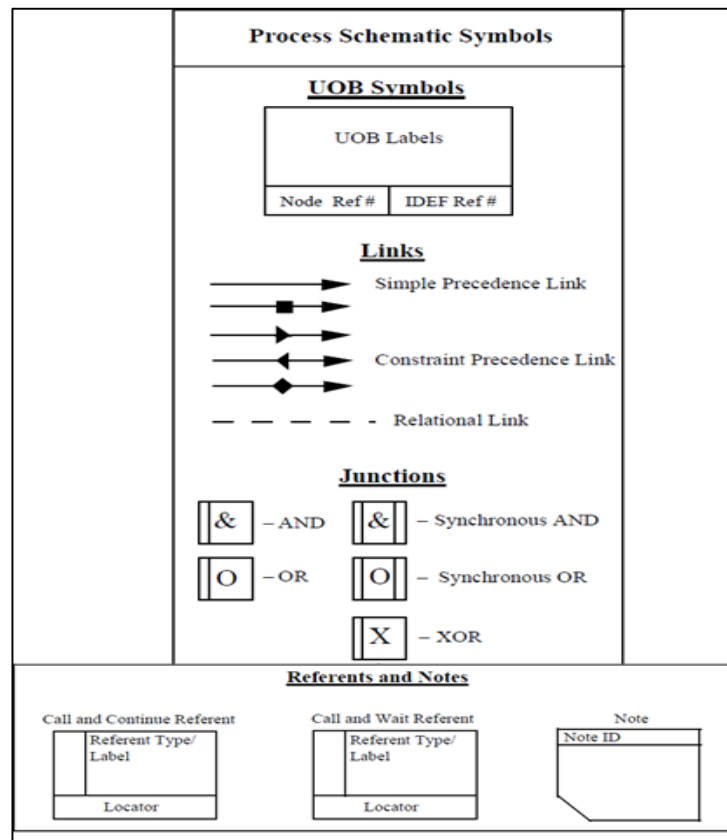


Diagram 23: IDEF3 - Basic Set of Elements [107]

The graph below provides an example regarding the use of IDEF3:

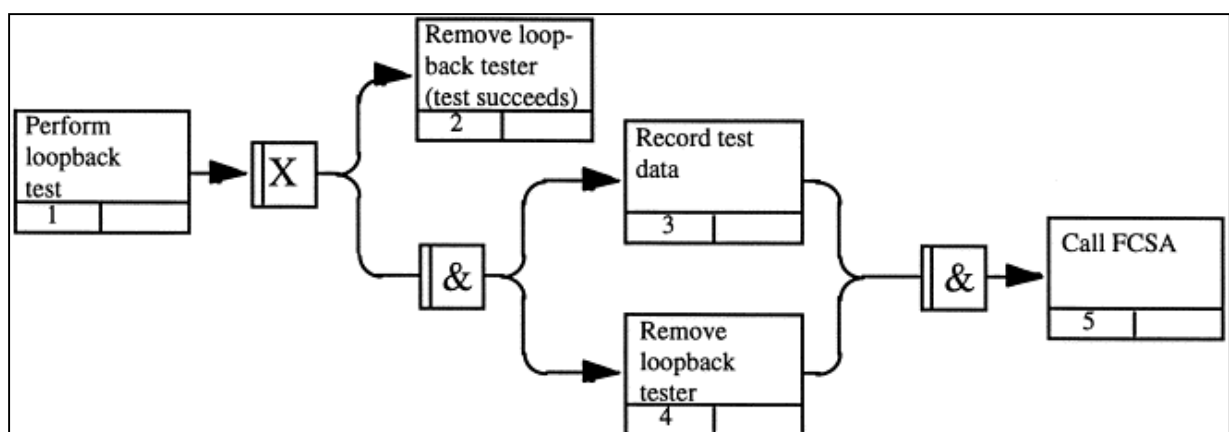


Diagram 24: IDEF3 - Model Example [Mo & Menzel, 108]

#### **2.2.2.3.2.4. ADVANTAGES AND DISADVANTAGES**

Similar to IDEF0, the strength of this technique is that is easy to learn given its use of only a few basic elements [105]. In addition, it is considered easy to use while being able to depict process-related information in a reliable and well-structured manner [103]. There is however a significant weakness associated with the use of IDEF3. It lacks the capability to illustrate many of the elements of business processes i.e. inputs, outputs, roles, events and resources [Plaia & Carrie, 109]. It is therefore limited in its ability to create models that are detailed enough to address the needs of the modelling applications that require the portrayal of these elements.

### **2.2.2.4. UNIFIED MODELLING LANGUAGE (UML) – ACTIVITY DIAGRAMS**

#### **2.2.2.4.1. INTRODUCTION**

The Unified Modelling Language (UML) represents a standard, established and well-defined modelling technique [Object Management Group, 110]. This technique was created and formalized by the Object Management Group and Rational Software. Currently, it is actively coordinated by the Object Management Group [19].

UML uses a collection of various different techniques (or languages) to capture the different perspectives and aspects of organizations. It is noted that although it was not originally created for the modelling of business processes, it is prominently used for this purpose. The UML Activity Diagram (UML-AD) represents the technique (or language) within this collection that is most used for the modelling of business processes [86].

#### **2.2.2.4.2. PURPOSE**

The purpose of UML-AD is to model both organizational and computational business processes [Rumbaugh et al., 111] in a precise, unambiguous and complete way [Preeti, 112]. In addition, it intends to enable users to portray, document and understand business processes from a requirements perspective [Dennis et al., 113].

#### **2.2.2.4.3. ELEMENTS**

UML-AD uses a basic set of elements to model business processes. They are [Ericsson, 114]:



### 1. Activity states

Activity states indicate the actions performed as part of the workflows of business processes.

### 2. Transitions

Transitions indicate the progression flow between activity states.

### 3. Object states

Objects indicate the information used or generated by the activities within the business processes.

### 4. Control states

The following control states are identified:

#### a. Decisions and guard conditions

Decisions indicate the joining of upstream activity states and also serve as the controls responsible for determining the downstream flow of the business processes. Guard conditions indicate the possible outcomes of these decisions.

#### b. Synchronization bars

Synchronization bars indicate the concurrent flow of various paths within business processes.

These synchronization bars can be related to converging or diverging flows.

#### c. Initial states (nodes)

Initial states indicate the starting point of sequences of activities within business processes.

#### d. Final states (nodes)

Final states indicate the starting point of sequences of activities within business processes.

The graph below depicts the basic set of elements associated with UML-AD:

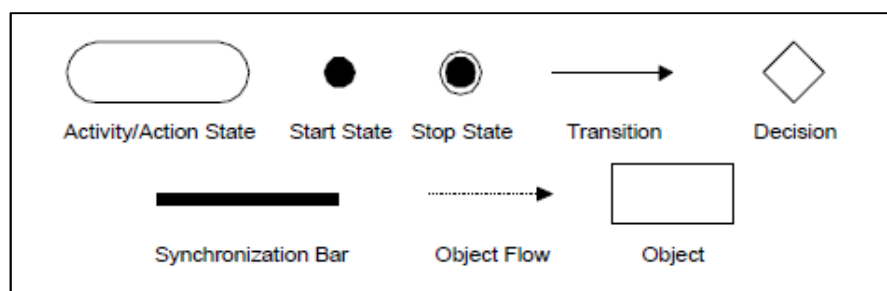


Diagram 25: UML-AD- Basic Set of Elements [Ferdian, 115]

The diagram below illustrates an example regarding the use of UML-AD to model business processes:

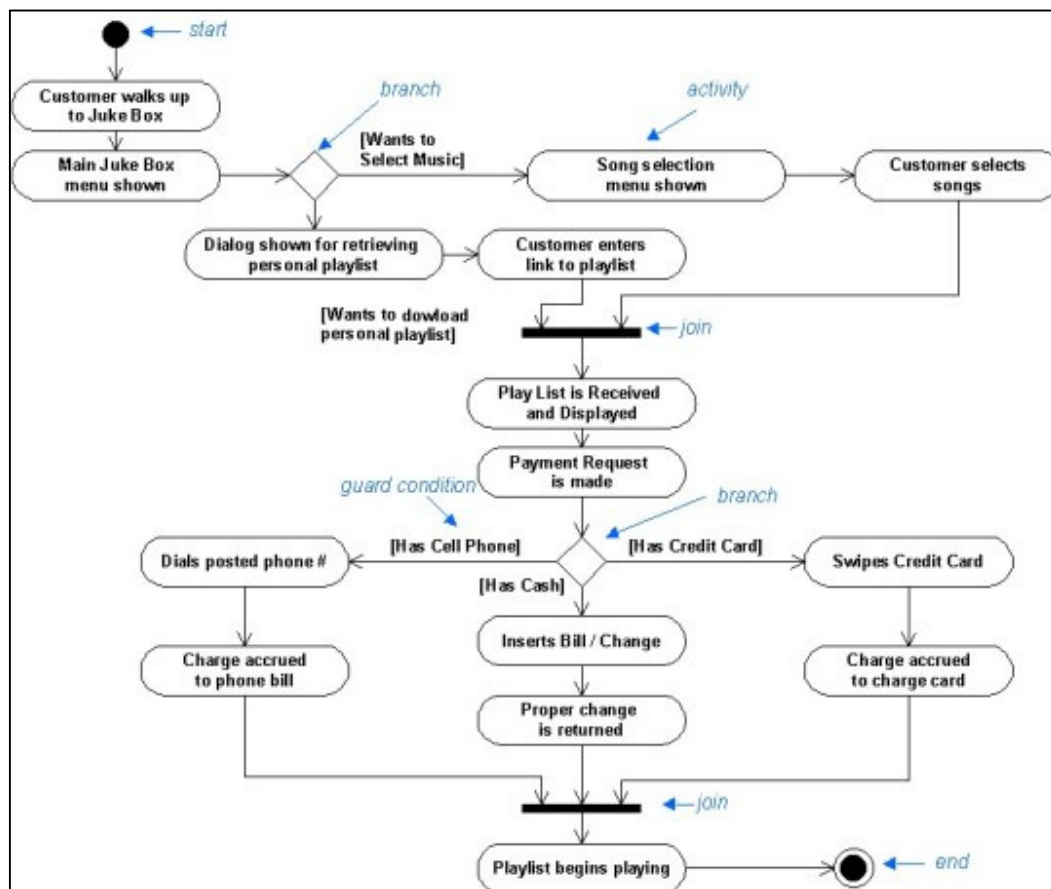


Diagram 26: UML-AD - Model Example [Gustavson, 116]

#### 2.2.2.4.4. ADVANTAGES AND DISADVANTAGES

There are significant benefits associated with the use of UML-AD to model business processes. UML-AD represents an effective and simple modelling technique that can be easily understood and used by various stakeholders, which may have different backgrounds i.e. systems development, business analysis and management. It can be used to model business processes that include complex and multiple decision points and sequence flows. According to Preeti, "activity diagrams are fairly easy to get the hang of, and will be useful for most projects because they plainly and moderately clearly demonstrate how things work." Unlike many diagramming techniques, these diagrams also enable the depiction of multiple choices and actors within a work flow, and they are easy for even non-technical users to follow " [112]. There is however also a disadvantage associated with this technique. It lacks semantics that can clearly differentiate between the resources and inputs of business processes. This limits its ability to depict these elements in a clear and unambiguous way.

#### **2.2.2.5. USE OF DESCRIBED BUSINESS PROCESS MODELLING TECHNIQUES**

The Business Process Modelling Techniques that were discussed represent some of the more:

##### **1. Investigated techniques**

It is important to describe the techniques that are investigated by the research community. This is important to ensure that a group of techniques is eventually considered that are in accordance with the future direction of Business Process Modelling research.

##### **2. Realistic techniques**

It is important to describe the techniques that are of a realistic nature. This is important to ensure that a group of techniques is eventually considered that are practical with regard to their use for the relevant modelling application.

##### **3. Renowned, applied and motivated techniques**

It is important to describe the techniques that are popularly and prominently used and that have proven and documented value. This is important to ensure that a group of techniques is eventually considered that can be beneficial to the relevant modelling application.

##### **4. Benchmarked techniques**

It is important to describe the techniques according to which newly developed techniques are commonly benchmarked. This is important to ensure that the considered group of techniques eventually represents those that are regarded as standard and sufficient techniques by industry leaders, business experts and the research community.

These characteristics served as means to validate the inclusion of the encountered techniques within the group of described techniques. In turn, this validation together with the advantages and disadvantages of the described techniques are used as inputs to determine which of the described techniques should be included in the group of considered techniques. The group of considered techniques is determined in a later chapter of this document.

# CHAPTER 3:

## RESEARCH DESIGN AND ANALYSIS

### 3.1. MEASUREMENT FRAMEWORK

*This section presents the development of a measurement framework that can be used to evaluate the suitability of the Business Process Modelling Techniques that are considered for specific modelling applications.*

Regarding their suitability for specific modelling applications, Business Process Modelling Techniques are evaluated based on the quality characteristics related to their depiction languages and their subsequent abilities to address the requirements of the relevant modelling applications. It is however noted that these quality characteristics are often evaluated in an isolated, uncoordinated, inconsistent and unclear manner. In relation to this, there are insufficient proposals concerning an approach to execute these evaluations. It is further recognized that there is a lack of formal measures to properly quantify the impact that these quality characteristics have on the abilities of their related techniques. Given these deficiencies, it becomes difficult to evaluate the suitability of the Business Process Modelling Techniques that are considered for specific modelling applications.

The table below outlines the fundamental meanings of the more prominent of these quality characteristics. These fundamental meanings are subsequently used as a platform to analyze, dissect, arrange and refine these quality characteristics. These actions are required in order to develop a formal measurement framework that can be used to evaluate the suitability of the Business Process Modelling Techniques that are considered for specific modelling applications.

**Table 2: Quality Characteristics – Fundamental Meanings**

<b>ACCURACY</b>	<i>Accuracy represents the ability of a Business Process Modelling Technique to design business process models that can convey the business processes of an organization in an accurate and truthful way.</i>
<b>COMPLETENESS</b>	<i>Completeness is the ability of a Business Process Modelling Technique to design business process models that can convey all the relevant business process information required by an organization.</i>
<b>COMPLEXITY</b>	<i>Complexity is the degree to which a Business Process Modelling Technique designs business process models that are difficult to design, understand and use.</i>

<b>EASE OF GENERATION</b>	<i>Ease of generation is the degree of ease associated with the design of business process models using a specific Business Process Modelling Technique.</i>
<b>EASE OF UNDERSTANDING</b>	<i>Ease of understanding is the extent to which a Business Process Modelling Technique is able to design business process models that are easy to understand.</i>
<b>EASE OF USE</b>	<i>Ease of use is the ability of a Business Process Modelling Technique to design business process models that are easy to use.</i>
<b>ECONOMY</b>	<i>Economy is the degree to which a Business Process Modelling Technique can design business process models that depict all the relevant business process information while using the minimum possible graphical notations.</i>
<b>EFFECTIVENESS</b>	<i>Effectiveness is the degree to which a Business Process Modelling Technique can design business process models that enables an organization to achieve its modelling objectives.</i>
<b>EFFICIENCY</b>	<i>Efficiency is the capability of a Business Process Modelling Technique to design business process models by using the minimum possible amount of resources.</i>
<b>EXPRESSIVENESS</b>	<i>Expressiveness is the degree to which a Business Process Modelling Technique is capable of designing business process models for any number and type of applications.</i>
<b>FLEXIBILITY</b>	<i>Flexibility is the ability of a Business Process Modelling Technique to design business process models that are easy to adapt in response to occurring business process changes.</i>
<b>FORMALITY</b>	<i>Formality is the ability of a Business Process Modelling Technique to design business process models that contain appropriate notations and conventions in aid of the differentiated illustration of all relevant business process elements.</i>
<b>SOFTWARE SUPPORT</b>	<i>Software support refers to the level of software support that can be offered to a Business Process Modelling Technique during the design or subsequent use of its associate business process models.</i>
<b>SUITABILITY</b>	<i>Suitability is the capability of a Business Process Modelling Technique to design business process models that are considered appropriate for a specific application.</i>

### **3.1.1. SUITABILITY, EFFECTIVENESS AND EASE OF USE**

It is fair to argue that a Business Process Modelling Technique is eventually considered suitable if it possesses the capability to create business process models that enable the relevant organization to achieve its modelling objectives. This implies that a Business Process Modelling Technique must first be regarded as effective before it can be regarded as suitable. In turn, it is argued that a Business Process Modelling Technique is effective if it can create business process models that are complete, efficiently generated, easy to understand and sustainable. Collectively, these four quality characteristics represent the ease with which a Business Process Modelling Technique can be used to design and support effective business process models.

Given these arguments, it is necessary to determine a Business Process Modelling Technique's:

- ease of use, which can serve as a suggestion of its ability to design and support effective business process models.
- effectiveness, which can serve as a suggestion of its suitability for a specific modelling application.

Considering this from another perspective, the suitability of a Business Process Modelling Technique can be suggested by measuring its effectiveness. In turn, the effectiveness of a Business Process Modelling Technique can be suggested by measuring its ease of use. Ultimately, the ease of use associated with a Business Process Modelling Technique is determined by the weighted average of its related sub-measurements (completeness, generating efficiency, ease of understanding and sustainability).

These sub-measurements are created through the analysis, dissection, organization and refinement of the quality characteristics (excluding suitability, effectiveness and ease of use) that were identified earlier. These quality characteristics are logically grouped and discussed below.

### **3.1.2. COMPLETENESS**

With reference to their modelling requirements, organizations identify specific process-related information that must be illustrated by their business process models. In turn, business process models that do not illustrate the process-related information required by their organizations are eventually considered to be incomplete. Ultimately, incomplete business process models cannot be effectively used by their organizations. The capability of a Business Process Modelling Technique to design complete business process models is therefore considered a critical quality characteristic that should be measured and evaluated.

Based on the aforementioned views, completeness can be measured by examining a Business Process Modelling Technique's ability to design business process models that include all the required informational elements. The required informational elements are determined based on the scope of the relevant modelling application. The following formula for completeness is defined:

$$T_{Xcomp} = \frac{TXrinf}{Orinf}, \text{ where}$$

$T_{Xcomp}$  = Completeness of Business Process Modelling Technique X, measured as a fraction.

$TXrinf$  = Number of required informational elements conveyed by business process models, which were designed through the use of Business Process Modelling Technique X.

$Orinf$  = Number of required informational elements stipulated by scope of modelling application.

\* Assumption = In order to isolate the performance of a specific technique in terms of its completeness, it is assumed that the process-related information that is captured during the data collection stage is sufficient enough to design complete business process models.

### 3.1.3. EASE OF GENERATION

In relation to its ease of use, it is understandable that a Business Process Modelling Technique should enable designers to easily generate their required business process models. In contrast, designers intend to avoid Business Process Modelling Techniques when their use is considered to be tedious, time-consuming and of an insufficient user-friendliness. It is therefore important to measure the ease with which a designer can generate the required business process models (for a specific modelling project) when a specific Business Process Modelling Technique is used. This ease of generation can be measured through the use of the following formula:

$$T_{Xegen} = \frac{TXrinf}{TXtime}, \text{ where}$$

$T_{Xegen}$  = Ease of generation attributed to Business Process Modelling Technique X, measured as the created informational elements per minute.

$TXtime$  = Actual time taken to design the required business process models using Business Process Modelling Technique X.

$T_{Xinf}$  = Number of required informational elements portrayed by business process models, when they were designed through the use of Business Process Modelling Technique X.

This measurement is subsequently used as a vital input for the design of the broader measurement regarding a Business Process Modelling Technique's efficiency. This broader measurement is developed and discussed below.

### 3.1.4. EFFICIENCY AND GENERATING EFFICIENCY

Organizations must achieve the objectives of their modelling projects through the use of the minimum possible amount of resources. This is necessary to ensure that the value of their modelling projects outweigh their inputs. Ultimately, this is required in order to motivate the execution of these projects.

The efficiency of a modelling project can be influenced by various factors. These factors include the Business Process Modelling Methodologies, -Technique and –Tools that are used to execute and support these projects. It is therefore argued that a Business Process Modelling Technique can only partially contribute to the overall efficiency of a modelling project. In turn, the overall efficiency of a modelling project cannot be used as a direct reflection regarding the efficiency of a Business Process Modelling Technique. The need therefore exists to define a new quality characteristic that can reflect the isolated impact that a Business Process Modelling Technique can have on the overall efficiency of a modelling project.

This new characteristic is defined as “generating efficiency”, which is identified as a quality characteristic that can reflect an isolated impact of a Business Process Modelling Technique on the overall efficiency of a modelling project. The generating efficiency of a Business Process Modelling Technique can be determined through the use of two types of measurements, which are both based on the ease of generation measurement. These two types are:

#### 1. Single technique evaluation

This measurement compares the actual designer-related cost to the budgeted designer-related cost. The following formula is defined for this measurement:

$$T_{Xegeff} = \frac{TXtime * Crop}{60 * (Mrbud)}, \text{ where}$$

$T_{Xegeff}$  = Generating efficiency of Business Process Modelling Technique X, measured as a fraction.



$T_{time}$  = Actual time taken to design the required business process models using Business Process Modelling Technique X.

$C_{rop}$  = Designer's cost per hour.

$M_{rbud}$  = Budgeted designer-related cost as defined within the modelling budget.

\*Assumption = This measurement assumes that a modelling budget has been defined for the relevant modelling project.

## 2. Multiple technique evaluation

This measurement compares the generating efficiency of each of the evaluated techniques to each other. The following formula is defined for this measurement:

$$T_{Xegeff} = \frac{TXegen}{Max\{T\{A;B;C;.....;X\}egen\}}, \text{ where}$$

$T_{Xegeff}$  = Generating efficiency of Business Process Modelling Technique X, measured as a fraction.

$T_{Xegen}$  = Ease of generation attributed to Business Process Modelling Technique X, measured as the created informational elements per minute.

$T_{\{A;B;C;.....;X\}egen}$  = Ease of generation attributed to each discrete alternative  $\{A;B;C;.....X\}$

It is important to note that this measurement ideally requires the use of the same Business Process Modelling Tool in support of each of the considered Business Process Modelling Techniques. The aim of this is to nullify the impact that these tools can have on the results of this measurement.

### 3.1.5. EASE OF UNDERSTANDING, COMPLEXITY AND ECONOMY

It is clear that in order to effectively use business process models, they must first be understood by their relevant users. This suggests that a Business Process Modelling Technique must enable the design of business process models that are easy to understand. In relation to this perspective, it is necessary to formulate a measurement that can be used to determine the ease with which users can understand business process models when they are designed through the use of a specific Business Process Modelling Technique. Two measurements are proposed in order to measure this ease of understanding.

They are:

### 1. Practical Measurement

The practical measurement involves the execution of a survey to determine the ease with which the relevant stakeholders can understand business process models when they were designed through the use of a specific Business Process Modelling Technique. This measurement can also be related to two types of evaluations:

#### a. Single technique evaluation

$$T_{Xeund} = \frac{TXsund}{TXnund}, \text{ where}$$

$T_{Xeund}$  = Ease of understanding related to Business Process Modelling Technique X, measured as a fraction.

$T_{Xsund}$  = Count of all the survey participants that consider the business process models related to Business Process Modelling Technique X as easy to understand, where “yes” =1 and “no”=0

$T_{nund}$  = Count of all the survey participants that are asked to comment on the ease of understanding related to Business Process Modelling Technique X.

#### b. Multiple technique evaluation

$$T_{Xeund} = \frac{TXcund}{\text{Max}\{T\{A;B;C;.....;X\}cund\}}, \text{ where}$$

$T_{Xeund}$  = Ease of understanding related to Business Process Modelling Technique X, measured as a fraction.

$T_{Xcund}$  = Count of all the survey participants that consider the business process models related to Business Process Modelling Technique X as the easiest to understand out of all the proposed alternatives.

$T_{\{A;B;C;.....;X\}cund}$  = Count of all the survey participants that consider the business process models related to Modelling Technique  $\{A;B;C;.....;X\}$  as the easiest to understand out of all the proposed alternatives.

## 2. Theoretical Measurement

The theoretical measurement involves an evaluation of a Business Process Modelling Technique's ability to design business process models that are economical and of the least possible complexity.

It is identified that an increase in the number of informational elements portrayed by business process models increases their complexity. In turn, an increase in the complexity of business process models decreases the ease with which they can be understood and used by their relevant users.

It is understandable that certain modelling applications require a large amount of informational elements that must be portrayed by their associated business process models. In order to address the requirements of these modelling applications, the design of complex business process models is therefore to some extent unavoidable. In addition, these business process models will remain of the same complexity regardless of the Business Process Modelling Technique that is used for their design. This can be considered as an " uncontrollable complexity " that is inherited by business process models from the requirements of their associated modelling applications.

It is fair to argue that the portrayal of additional informational elements beyond the requirements of modelling applications may sometimes be useful, but most of the time they only clutter business process models with information that is not required. This leads to the design of uneconomical business process models that are considered too complex for the purposes of their associated modelling applications. It is identified that the portrayal of these additional informational elements is the result of the Business Process Modelling Technique that is used to design the required business process models. In this regard, business process models inherit a " controllable complexity " from the Business Process Modelling Technique that is used for their design. Ultimately, Business Process Modelling Techniques must be able to design complete business process models while still being able to ensure that they are economical and of the least possible " controllable complexity ". This implies that the requirements that are stipulated for modelling applications should serve as the upper-limit with regard to the informational elements that must be conveyed by their associated business process models.

Based on the aforementioned perspectives, the following measurement is defined to determine the economy associated with the use of a Business Process Modelling Technique for a specific modelling application:

$$T_{Xecon} = 2 - \left( \frac{TX_{ainf}}{Or_{inf}} \right), \text{ where}$$

$T_{Xecon}$  = Economy of Business Process Modelling Technique X, measured as a fraction.

=If  $T_{Xecon} > 1$ ,  $\approx 1$

$T_{Xainf}$  = Number of all the informational elements that are conveyed by business process models when they were designed through the use of Business Process Modelling Technique X.

$O_{rinf}$  = Number of informational elements that must be portrayed as stipulated by the scope of the relevant modelling application.

This measurement of economy is therefore used to suggest the ability of a Business Process Modelling Technique to design business process models that are of the least possible “controllable complexity”. Ultimately, it is used as a theoretical measurement to determine the ease of understanding associated with the relevant Business Process Modelling Technique.

### **3.1.6. FORMALITY, EXPRESSIVENESS, FLEXIBILITY, SOFTWARE SUPPORT AND SUSTAINABILITY**

In order to standardize and sustain their modelling practices and outputs, it is considered vital for organizations to consistently use the same Business Process Modelling Technique for both their current and future modelling projects. Evaluating the ease with which a Business Process Modelling Technique can be used should therefore not be limited to its current use. It should also include an evaluation of its future use, which is also considered significant. In order to measure this future use, it is necessary to define a new quality characteristic. This quality characteristic is defined as the “sustainability” of a Business Process Modelling Technique.

The initial modelling projects of organizations generally represent the design of business process models that portray their business processes at a high level of abstraction. As their business process maturities improve, organizations require business process models that can portray more details concerning their business processes. In addition, the dynamic nature of organizations can lead to the need to modify their current business processes and therefore also the details included in their business process models. Business Process Modelling Techniques that are limited with regard to their amount of well-defined semantics may struggle to address the increasing or changing illustration requirements of organizations. Ultimately, these techniques are limited with regard to their use for future purposes.

The formality (amount of well-defined semantics) of a Business Process Modelling Technique can therefore give insight into its capability to address the possible increasing or changing illustration requirements of organizations. This implies that the formality of Business Process Modelling Techniques

can be used to suggest both their expressiveness and flexibility. Ultimately, the formality of Business Process Modelling Techniques represents a sub-measurement of their sustainability.

It is understandable that the evaluation of a single technique's formality is difficult given that it is impossible to accurately predict the specific illustration requirements of future modelling applications. In addition, without the referencing platform provided by the comparison of multiple techniques, it becomes difficult to put into perspective the formality of a specific technique. Based on these views, the formality of a Business Process Modelling Technique can be suggested by the measurement below:

$$T_{Xform} = \frac{TXcsem}{Max\{T\{A;B;C;.....;X\}csem\}}, \text{ where}$$

$T_{Xform}$  = Level of formality related to Business Process Modelling Technique X, measured as a fraction.

$T_{Xcsem}$  = Count of all well-defined semantics related to Business Process Modelling Technique X.

$T_{\{A;B;C;.....;X\}csem}$  = Count of all well-defined semantics related to Business Process Modelling Technique  $\{A;B;C;.....;X\}$ .

Based on the increasing technology-based operations within organizations, it will become more and more important for Business Process Modelling Techniques to possess integration capability with the software systems that are used by organizations. With reference to their sustainable use, it is therefore also important to evaluate the software support that is available for Business Process Modelling Techniques within organizations. The following measurement related to software support is defined:

$$T_{Xsoft} = T_{Xyint}, \text{ where}$$

$T_{Xsoft}$  = Software support related to Business Process Modelling Technique X, measured as a binary value (0 or 1).

$T_{Xyint}$  = Integration is possible between Business Process Modelling Technique X and the Enterprise Resource Planning (ERP) system that is used by the relevant organization, True = 1, False = 0.

### 3.1.7. ACCURACY

Business process models are designed based on the outputs of the data collection activity. The accuracy of business process models is therefore merely a reflection of the accuracy of these outputs.

It is subsequently argued that the inaccuracy of business process models cannot be effectively isolated

to the Business Process Modelling Technique that is used for their design. Ultimately, this warrants the exclusion of accuracy as a measurement from the developed framework.

### 3.1.8. CONSOLIDATION OF MEASUREMENTS

Based on the analysis, dissection, organization and refinement of some of the most prominent quality characteristics related to the depiction languages of Business Process Modelling Techniques, the measurement framework below is suggested. This measurement framework can be used to evaluate the suitability of the Business Process Modelling Techniques that are considered for specific modelling applications.

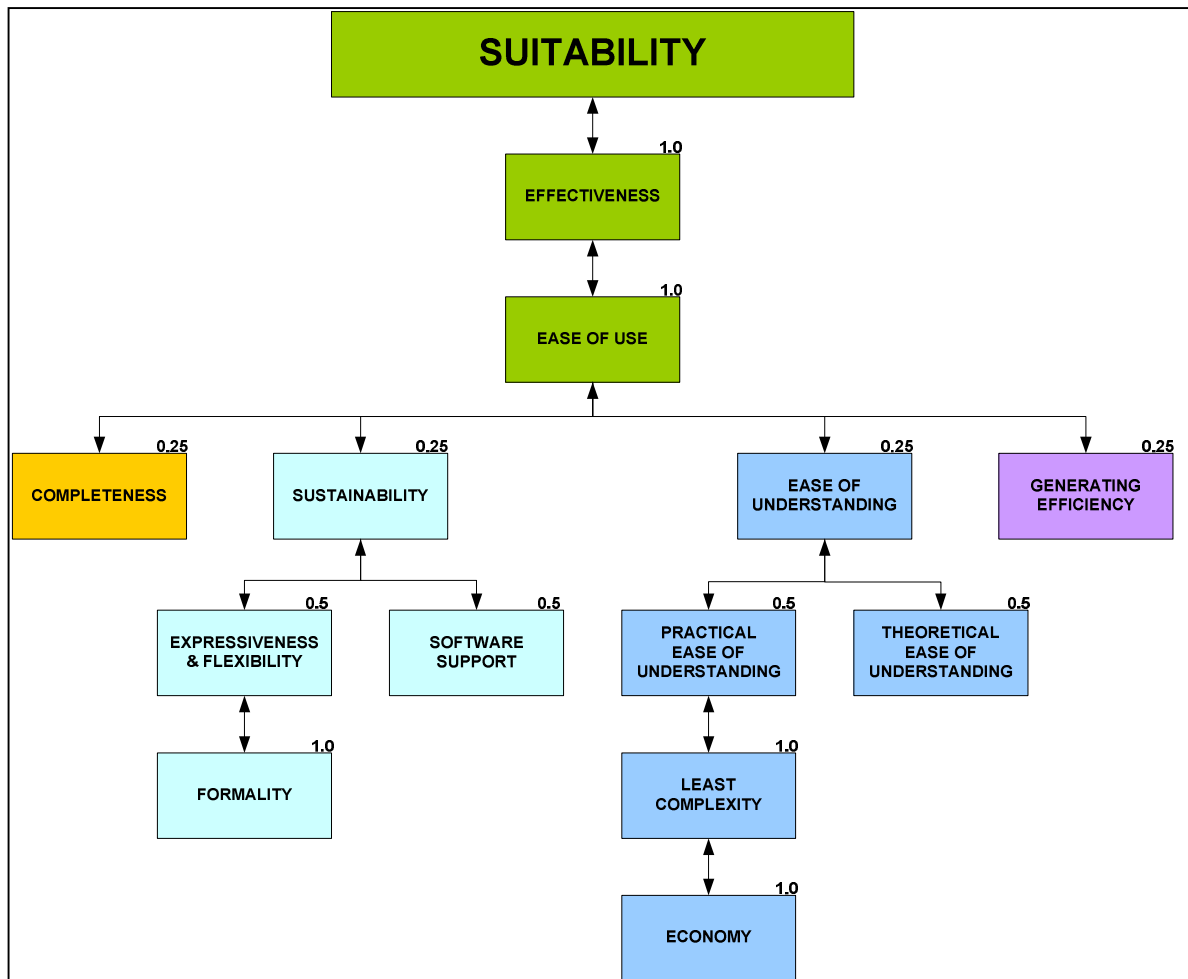


Diagram 27: Business Process Modelling Techniques - Measurement Framework

The measurements contained within this framework are assigned specific weights (top right corner of measurements). These weights are assigned to the measurements based on one of two arguments.

These arguments are:

1. The relevant measurement can single-handedly be used to measure its parent characteristic. Based on the earlier discussions, this includes the weights that are assigned to:
  - effectiveness
  - ease of use
  - formality
  - economy
  - least complexity
2. It is possible that a biased weight distribution among a group of sub-measurements coupled with higher measured capabilities in some (but not all) of these sub-measurements, can give a false impression regarding the overall capability of their parent characteristic.

The table below serves as an example of such a false impression. Evaluating the ease of use of both these techniques, Technique 2 is identified as the technique with the higher capability in terms of ease of use. This result is due to a biased weight distribution and a higher capability in terms of its associated completeness. It can therefore be misinterpreted that Technique 2 is superior to Technique 1 with regard to all the sub-measurements of ease of use. This is possible albeit Technique 2 performed much worse than Technique 1 in three out of the four sub-measurements.

**Table 3: Measurement Framework – Impact of Biased Weight Distribution**

BIASED WEIGHT DISTRIBUTION						
<b>Technique 1</b>		Completeness	Generating Efficiency	Ease of Understanding	Sustainability	
	Measured Capability	0.65	0.65	0.65	0.65	
	Weight	0.25	0.25	0.25	0.25	Total Ease of Use
						<b>0.65</b>
<b>Technique 2</b>		Completeness	Generating Efficiency	Ease of Understanding	Sustainability	
	Measured Capability	0.9	0.35	0.35	0.35	
	Weight	0.6	0.1	0.2	0.1	Total Ease of Use
						<b>0.68</b>

In order to eliminate the possibility of such misinterpretations, it is argued that certain sub-measurements represent a collective group that must have the same weights in order to validate the measurement of their parent characteristic. This is motivated by the table below, which indicates the impact that a uniform weight distribution can have on the same evaluation.

**Table 4: Measurement Framework – Impact of Uniform Weight Distribution**

UNIFORM WEIGHT DISTRIBUTION						
<b>Technique 1</b>		Completeness	Generating Efficiency	Ease of Understanding	Sustainability	
	Measured Capability	0.65	0.65	0.65	0.65	
	Weight	0.25	0.25	0.25	0.25	Total Ease of Use
						<b>0.65</b>
<b>Technique 2</b>		Completeness	Generating Efficiency	Ease of Understanding	Sustainability	
	Measured Capability	0.9	0.35	0.35	0.35	
	Weight	0.25	0.25	0.25	0.25	Total Ease of Use
						<b>0.49</b>

Based on the earlier discussions, this includes the weights that are assigned to the following groups:

- completeness, sustainability, ease of understanding and generating efficiency as a collective group of sub-measurements that is used to measure ease of use.
- software support and expressiveness & flexibility as a collective group of sub-measurements that is used to measure sustainability.
- theoretical ease of understanding and practical ease of understanding as a collective group of sub-measurements that is used to measure ease of understanding.

## 3.2. MODELLING APPLICATION

*This section outlines the scope of the specific modelling application.*

Shoprite Checkers (Pty) Ltd. has identified the need to formally define and document the current business processes of the Checkers Supermarket –Stellenbosch.

The execution of this modelling project must lead to the design of business process models that can be used to understand and subsequently analyze the operations that are executed by this supermarket. In addition, these business process models must provide the platform for future modelling efforts as well as the roll-out of standard procedures across the various supermarkets of Shoprite Checkers (Pty) Ltd.

It has been identified through the collaboration with the relevant project leader that the modelling project must focus on defining and documenting the core business processes of the Checkers Supermarket-Stellenbosch. In addition, the designed business process models must ideally portray the following informational elements:

- the events that start and end the activities within the core business processes
- the activities that are contained within the core business processes



- the sequences / interdependencies between the activities that are contained within the core business processes
- the responsibilities that are associated with the activities that are contained within the core business processes
- the resources and inputs that are used by the core business processes
- the outputs of the activities that are contained within the core business processes
- the customers of the outputs that are created by the core business processes

### 3.3. CONSIDERED TECHNIQUES

*This section identifies the group of Business Process Modelling Techniques that are considered for the specific modelling application.*

Based on the aforementioned validation, advantages and disadvantages of the described techniques as well as the scope of the relevant modelling application, the group of described techniques are reduced to a group of techniques that are considered for the relevant modelling application. The techniques included in the group of considered techniques are the following:

- **Business Process Modelling Notation (BPMN)**

BPMN should provide the Checkers Supermarket – Stellenbosch with a consolidated, standard and flexible technique to design business process models that can be easily understood and used by its various stakeholders. In addition, it possesses a rich range of formal semantics that should be able to address most of its informational requirements.

- **Event-Driven Process Chains (EPC's)**

Event-driven Process Chains should provide the Checkers Supermarket – Stellenbosch with a widely-accepted, popular and flexible technique to design business process models that can be easily understood and used by its various stakeholders. Although there are limitations concerning its amount of formal semantics, it is still considered superior to IDEF0 and IDEF3 in this regard.

- **Unified Modelling Language Activity Diagrams (UML-AD)**

UML-AD can provide the Checkers Supermarket – Stellenbosch with an effective, simple and popular technique to design business process models that can be easily understood and used by their various stakeholders. Although there are limitations concerning its ability to depict resources and inputs in a

clear and unambiguous way, it is still considered superior to IDEF0 and IDEF3 concerning the overall amount of required informational elements that it can portray.

The Business Process Modelling Techniques that are excluded from the group of considered techniques are the following:

- **Integrated Definition Method 0 (IDEF0)**

Given that IDEF0 business process models must consist of 3 to 6 functions, it is constrained with regard to the level of flexibility, adaptability and detail it can offer to the Checkers Supermarket – Stellenbosch. In addition, it does not allow for the natural representation of timing, sequencing and decision logic, which makes it difficult for users not familiar with the technique to understand.

- **Integrated Definition Method 3 (IDEF3)**

IDEF3 lacks the capability to portray many of the elements of business processes i.e. inputs, outputs, roles, events and resources. It is therefore the most limited of the described techniques in terms of ability to design business process models that address the informational requirements of the Checkers Supermarket – Stellenbosch.

## **3.4. DATA COLLECTION**

*This section presents the outputs of the data collection activity.*

Given the identified scope of the specific modelling application, the data collection activity focuses on data relevant to the core business processes of the Checkers Supermarket – Stellenbosch. Based on this data, the following core business processes are identified and described:

### **3.4.1. RECEIVING OF GOODS**

The receiving of goods procedure is initiated by the arrival of stock items at the receiving bays of the supermarket. These stock items emanate from either an external supplier or the warehouse of Shoprite Checkers Pty Ltd.

The next available Receiving Clerk collects the supplier invoice from the Supplier Representative and delivers it to the office of the Data Administration Clerks. The next available Data Administration Clerk receives the invoice and enters the invoice number into the supermarket's operating system ("Operation Better Store System") in order to retrieve the invoice and order details.

In the case where the invoice and order details are not retrievable, the Data Administration Clerk notifies the Branch Manager and the Controllers relevant to the identified stock types (i.e. fruit and vegetables, non-foods, perishables, deli, meat, bakery, fish, groceries) regarding the arrival of the relevant stock items. These entities then decide whether the stock items should be received or not. Given the decision to receive the stock items, the Data Administration Clerk captures the supplier invoice on the system and hands it back to the relevant Receiving Clerk for further downstream activities (indicated later i.e. control, quality assurance, and formal receipt of goods). Given the decision not to receive the stock items, the Data Administration Clerk notifies the relevant Receiving Clerk that the stock items will not be received. The Receiving Clerk subsequently notifies the Supplier Representative of this decision and the process is concluded.

In the case where the invoice and order details are retrievable, the Data Administration Clerk compares the order quantities, prices and stock types specified by the system invoice to those specified by the supplier invoice. Based on this comparison, the following outcomes are possible:

## **1. External Suppliers**

### **a. Supplier invoice and system invoice match.**

- The Data Administration Clerk approves the supplier invoice and hands it back to the relevant Receiving Clerk.

### **b. Supplier invoice specifies wrong stock types or either higher prices or quantities.**

- The Data Administration Clerk removes the wrong items or either adjusts the prices or quantities on the supplier invoice. The adjusted invoice is handed back to the relevant Receiving Clerk.

### **c. Supplier invoice specifies lower quantities.**

- The Data Administration Clerk creates a shortage notification on the system. The Data Administration Clerk gives a printed copy of the shortage notification as well as the supplier invoice to the relevant Receiving Clerk. The Receiving Clerk delivers the copy of the shortage notification to the Supplier Representative.

## **2. Warehouse**

### **a. Supplier invoice and system invoice match.**

- The Data Administration Clerk approves the supplier invoice and hands it back to the relevant Receiving Clerk.

**b. Supplier invoice specifies wrong item types or higher quantities.**

- The Data Administration Clerk adds the stock types and quantities to the system invoice. This is due to the fact that the relevant items or quantities would in any case be ordered from the warehouse in the future. This adjustment on the system will however influence the future order levels of the relevant stock types. The invoice is handed back to the relevant Receiving Clerk.

**c. Supplier invoice specifies lower quantities.**

- The Data Administration Clerk phones the warehouse and informs them of the relevant shortage. This leads to a future investigation into this shortage to determine the validity of the shortage claim. This investigation however occurs outside the boundaries of the receiving of goods procedure. The invoice is handed back to the relevant Receiving Clerk.

Upon receipt of the processed invoice, the relevant Receiving Clerk executes the necessary controlling activity. This involves ensuring that only the stock items indicated by the processed invoice are received. During this controlling activity, the quality of the stock items is also examined. The stock items that are not of the required quality will not be received and the identified issues concerning these stock items are communicated to the relevant Data Administration Clerk. The Data Administration Clerk subsequently creates a shortage notification regarding these stock items within the operating system and gives a printed copy of the shortage notification to the relevant Receiving Clerk. The relevant Receiving Clerk gives this printed copy of the shortage notification to the Supplier Representative.

Once the controlling and quality assurance activities are completed, the relevant Receiving Clerk stamps the supplier invoice with a Goods Received Number (GRN). The Supplier Representative signs the invoice and the goods are then formally received by the supermarket. This marks the conclusion of the receiving of goods procedure.

### **3.4.2. TRANSFER AND PRESENTATION OF GOODS**

The transfer and presentation procedure is initiated by the formal receipt of stock items at the receiving bays of the supermarket. The subsequent transfer paths of these stock items are determined based on the type of stock items that are received. There are two possible transfer paths:

**1. Deli-, Bakery-, Meat-or Fish Department.**

In the case where the received stock items represent stock types intended for these departments, the Receiving Clerk notifies the relevant Controllers (i.e. Deli Controller, Bakery Controller etc.) of the received stock items. This triggers the collection of the received stock items by the relevant Controllers

or their associated Department Staff. The Controllers or their associated Department Staff execute the security sign-off that is required to transfer the stock items from the receiving bays to their associated departments. Upon completion of this sign-off, the stock items are transferred to the storage facilities located within the relevant departments. These stock items reside within these storage facilities until they are required for the relevant downstream activities. Based on the type of stock items that was received, the transfer path and subsequent activity may be either of the following:

**a. Presentation of goods.**

- This activity and path is relevant to stock items that do not require any physical transformation, that are already in their sellable form and that can be classified as finished goods. These stock items are directly transferred from the relevant storage facilities to their designated display areas (i.e. fridges, casings, racks, shelves etc.). The transfer of these stock items from the relevant storage facilities to their designated display areas is triggered by the depletion of similar stock items within the designated display areas. The ultimate outcome of this transfer is that the relevant type of stock items is again available for purchase by the external customers. This concludes the transfer and presentation procedure.

**b. Production and presentation of goods.**

- This activity and path is relevant to stock items that require some sort of physical transformation before they can be sold. These stock items are transferred from the storage facilities to the areas within their associated departments where the physical transformation must take place. Upon completion of this physical transformation, the stock items are classified as finished goods and can be sold. The production and subsequent transfer of these goods to their designated display areas (i.e. fridges, casings, racks, shelves etc.) is triggered by the depletion of goods within the designated display areas. The ultimate outcome of this transfer is that the relevant type of stock items is again available for purchase by the external customers. This concludes the transfer and presentation procedure.

**2. Perishables, Groceries, Non-foods**

In the case where the received stock items represent stock types meant for these departments, the Receiving Clerk notifies the Storage Staff (located within the central storage facilities) of the received stock items.

The Storage Staff executes the security sign-off that is required to move the stock items from the receiving bays to the central storage facilities. Upon completion of this sign-off, the stock items are

transferred to the central storage facilities and reside there until they are required for the relevant downstream activities. It is important to note that these stock items signify those that do not require any physical transformation, that are already in their sellable form and that can be classified as finished goods.

The Shelf Packer relevant to the stored stock items continuously monitors the level of depletion that is associated with similar stock items on the supermarket floor. Given the situation where these stock items have not yet been depleted, no action is taken. Given the situation where these stock items are depleted, the Shelf Packer goes to the central storage facilities and collects the required stock items for the necessary replenishment. The Shelf Packer executes the security sign-off that is required to move the stock items from the central storage facilities to the supermarket floor. The ultimate outcome of this transfer is that the relevant type of stock items is again available for purchase by the external customers. This concludes the transfer and presentation procedure.

### **3.4.3. SALES**

The sales procedure is initiated by an External Customer's request for purchase of a sellable stock item at one of the various points of sale within the supermarket. The cashier situated at the relevant point of sale uses the barcode scanner to scan the relevant stock item and retrieves the price of the stock item from the Point of Sale System ("POS System"). The Cashier communicates the price to the External Customer and establishes the method of payment, which is then captured in the Point of Sale System. Based on the method of payment, one of the following downstream activities and paths are relevant:

#### **1. Payment by cash**

- a.** In the case where the External Customer supplies the Cashier with the correct amount of cash, the Cashier places the cash into the till storage unit and enters the payment amount into the Point of Sale System. The Cashier then supplies the External Customer with a receipt of the sales transaction. This concludes the sales procedure.
- b.** In the case where the External Customer supplies the Cashier with a larger amount than the purchase price, the Cashier places the cash into the till storage unit and enters the payment amount into the Point of Sale System. The Cashier removes the change amount from the till storage unit and hands it to the External Customer together with the receipt of the sales transaction. This concludes the sales procedure.

## **2. Payment by debit or credit card**

In the case where an External Customer pays by debit or credit card, the Cashier enters the relevant card into the card machine. The Cashier types in the payment amount and the account type into the card machine. The External Customer thereafter enters the required security pin. The following subsequent scenarios are identified:

- a. Given the approval of the transaction, the External Customer signs a copy of the machine-generated transaction slip and hands it back to the Cashier. The Cashier hands an unsigned copy of the transaction slip to the External Customer together with the receipt of the sales transaction. This concludes the sales procedure.
- b. Given the rejection of the transaction, the Cashier requests a different method of payment from the External Customer. In the case where the External Customer can supply such a method, the relevant activity and path is followed. In the case where one cannot be supplied, the sale is voided and the sales procedure is concluded.

## **3. Payment by savings stamp or a voucher**

In the case where an External Customer pays with a savings stamp or voucher, it is handed to the Cashier. The Cashier issues the External Customer with a receipt of the sales transaction. This concludes the sales procedure.

## **4. Payment by cheque**

In the case where an External Customer pays by cheque, the cheque is received by the Cashier together with a confirmation of identification (Identification Document). The Cashier issues the External Customer with a receipt of the sales transaction. This concludes the sales procedure.

### **3.4.4. ORDERING OF GOODS**

The Data Administration Clerk initiates the ordering of goods procedure by retrieving the suggested order catalogues from the supermarket's operating system ("Operation Better Store System"). These generic order catalogues are loaded onto the operating system by Shoprite Checkers Pty Ltd. and represent suggested order quantities regarding the stock items of each department within the supermarket. These suggested order quantities are established through a time-based analysis of each department's sales.

In the case where the buyer's negotiation stipulates the continuous occurrence of a " Electronic Data Interchange (EDI) " order, the quantities suggested by the relevant catalogues are automatically ordered from the relevant suppliers. In turn, no action is required from the supermarket and the ordering procedure is concluded.

In the case where an " Electronic Data Interchange (EDI) " order is not applicable, the relevant order catalogues are collected by the Controllers of the relevant departments. The relevant Controllers use these order catalogues, the actual stock available (both on supermarket floor and in storage facilities) and the target production quantities (if applicable) to determine the actual required order quantities of the stock items relevant to their departments. Given the situation where the actual required order quantities match those suggested by the catalogues, no adjustments are required. Given the situation where the actual required order quantities do not match those suggested by the catalogues, the relevant Controllers adjust the suggested orders. Upon completion of either of these activities, the relevant Controllers deliver the processed orders to the Data Administration Clerk. The Data Administration Clerk submits the orders to the relevant suppliers. This concludes the ordering procedure.

### **3.4.5. ACCURACY OF BUSINESS PROCESS DESCRIPTIONS**

In an attempt to ensure the accuracy of the business process descriptions, the data collected during the interviews with the process participants (internal perspectives) is compared to the data collected during the observations of the core business processes (external perspectives). This comparison is executed in order to identify, address and eliminate the discrepancies between the data relevant to these two perspectives. This comparison represents an iterative process whereby the data of both these perspectives are reviewed and refined until they correspond. The business process descriptions therefore signify the collective accuracy of these two perspectives.

## **3.5. DESIGN OF BUSINESS PROCESS MODELS**

*This section presents the design of the required business process models.*

### **3.5.1. BUSINESS PROCESS MODELLING TOOL**

It is important that an evaluation regarding the group of considered Business Process Modelling Techniques should not be impacted by the Business Process Modelling Tool that is used in support of these techniques. It is therefore important that the same Business Process Modelling Tool should be



used in support of each of these techniques. The Business Process Modelling Tool that is used in support of these techniques is MS Visio 2010. MS Visio 2010 contains all of the necessary notations and layouts for the design of the required business process models. It is relatively inexpensive and it is opinionated that it is a sufficient tool for organizations of a lower business process maturity. In relation to an increase of their business process maturity to a managed or optimized level, organizations can consider the use of dynamic Business Process Modelling Tools. It is however opinionated that dynamic Business Process Modelling Tools are too complex for the modelling requirements of organizations that possess a lower business process maturity.

### **3.5.2. BUSINESS PROCESS MODELLING TECHNIQUES**

It is important to note that all of the considered techniques are respectively used to design distinct sets of business process models. The purpose of these distinct sets is to enable equivalent evaluations regarding the relevant techniques and their related abilities. These equivalent evaluations provide the platform to objectively compare the considered techniques in terms of their suitability for the specific modelling application.

### **3.5.3. ACCURACY OF BUSINESS PROCESS MODELS**

Based on the descriptions of the core business processes, the required business process models are designed. In an attempt to ensure the accuracy of the business process models, the business process models are continuously compared to the descriptions of the core business processes. This activity represents an iterative process whereby the business process models are continuously reviewed and refined until they correspond with the descriptions of the core business processes.

### **3.5.4. REPRESENTATIVE NATURE OF BUSINESS PROCESS MODELS**

Considering that the various supermarkets of Shoprite Checkers (Pty) Ltd. should share the same strategic and operational objectives, it is fair to argue that their business processes should be the same. Based on this view, it is also argued that the business process models of one supermarket should be the same as the business process models of any of the other supermarkets. Ultimately, it is implied that the business process models concerning the core business processes of the Checkers Supermarket – Stellenbosch should be representative of the core business processes of any of the other supermarkets of Shoprite Checkers (Pty) Ltd.

### **3.5.5. DESIGNED BUSINESS PROCESS MODELS**

Based on the descriptions of the core business processes, distinct sets of the required business process models are designed. The diagrams below depict these distinct sets of business process models:

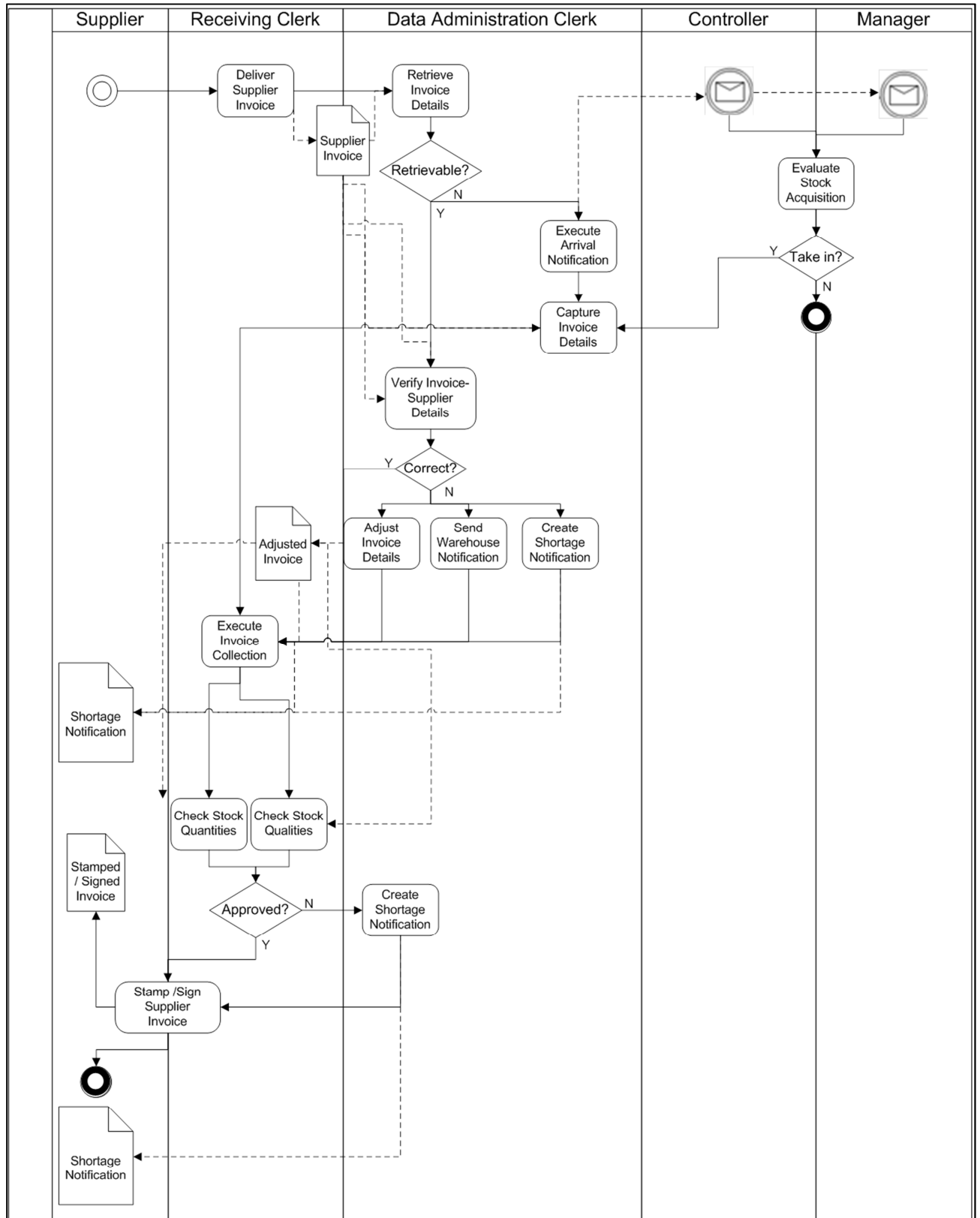


Diagram 28: BPMN - Receiving Process

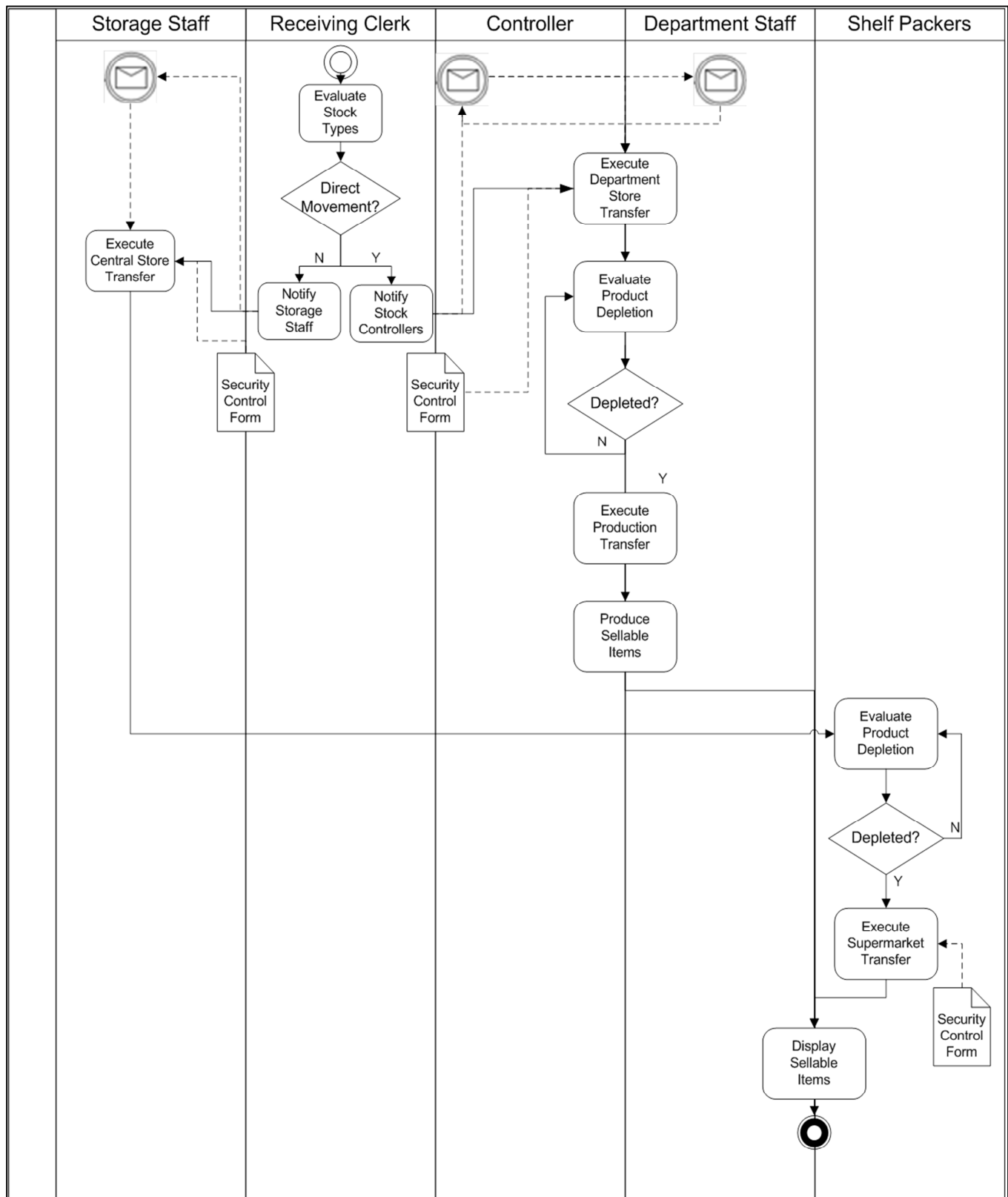


Diagram 29: BPMN - Transfer and Presentation Process

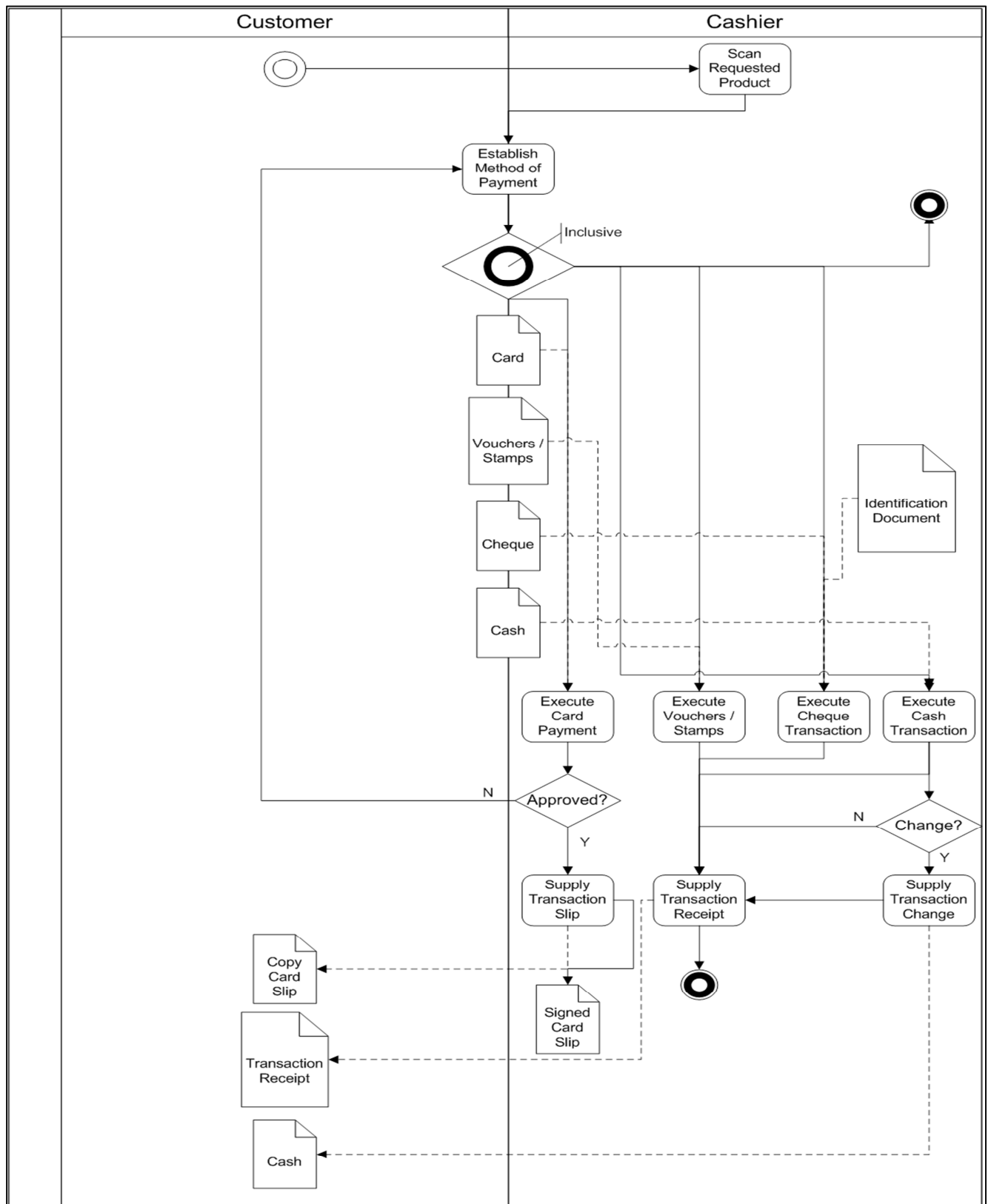


Diagram 30: BPMN - Sales Process

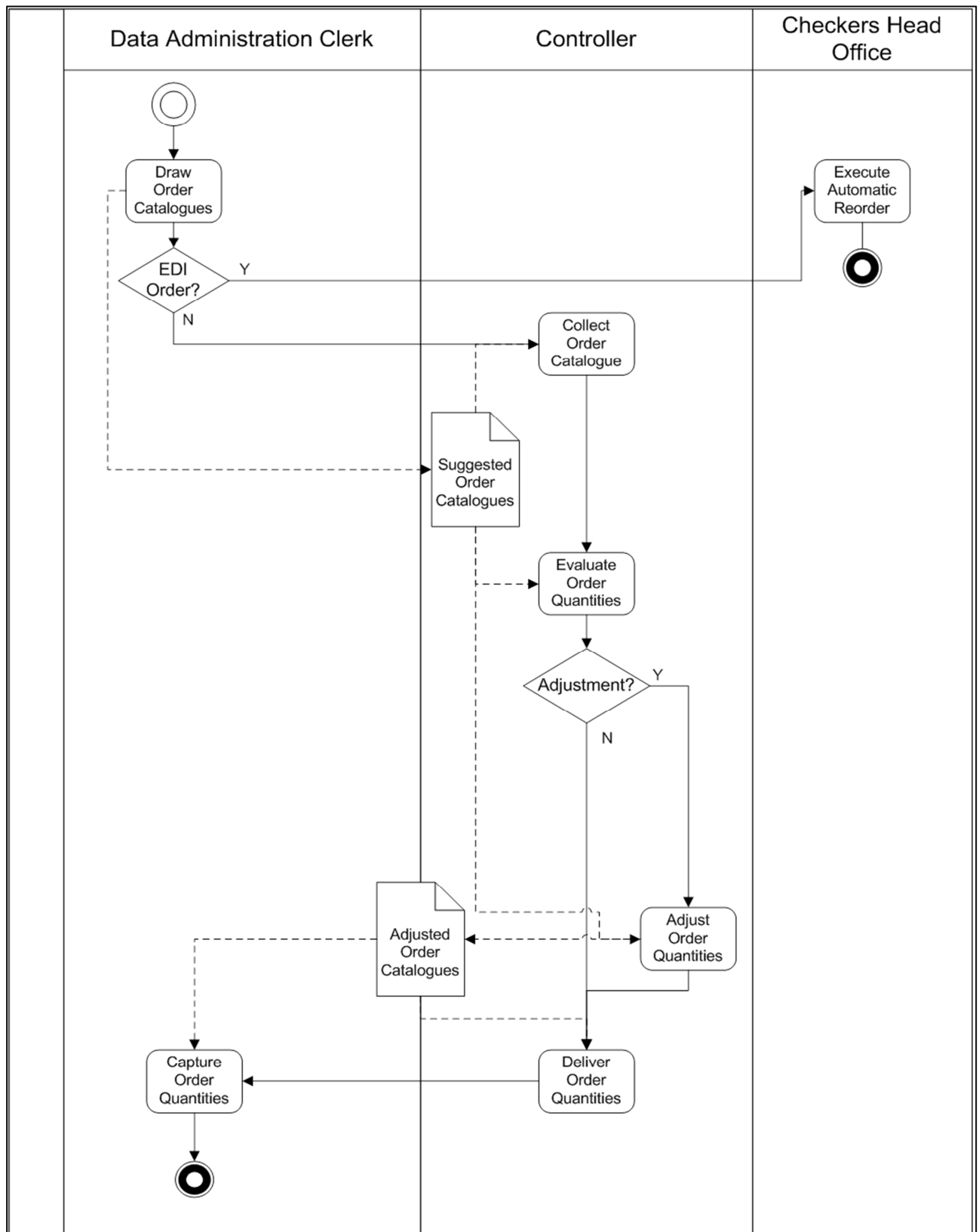


Diagram 31: BPMN - Ordering Process

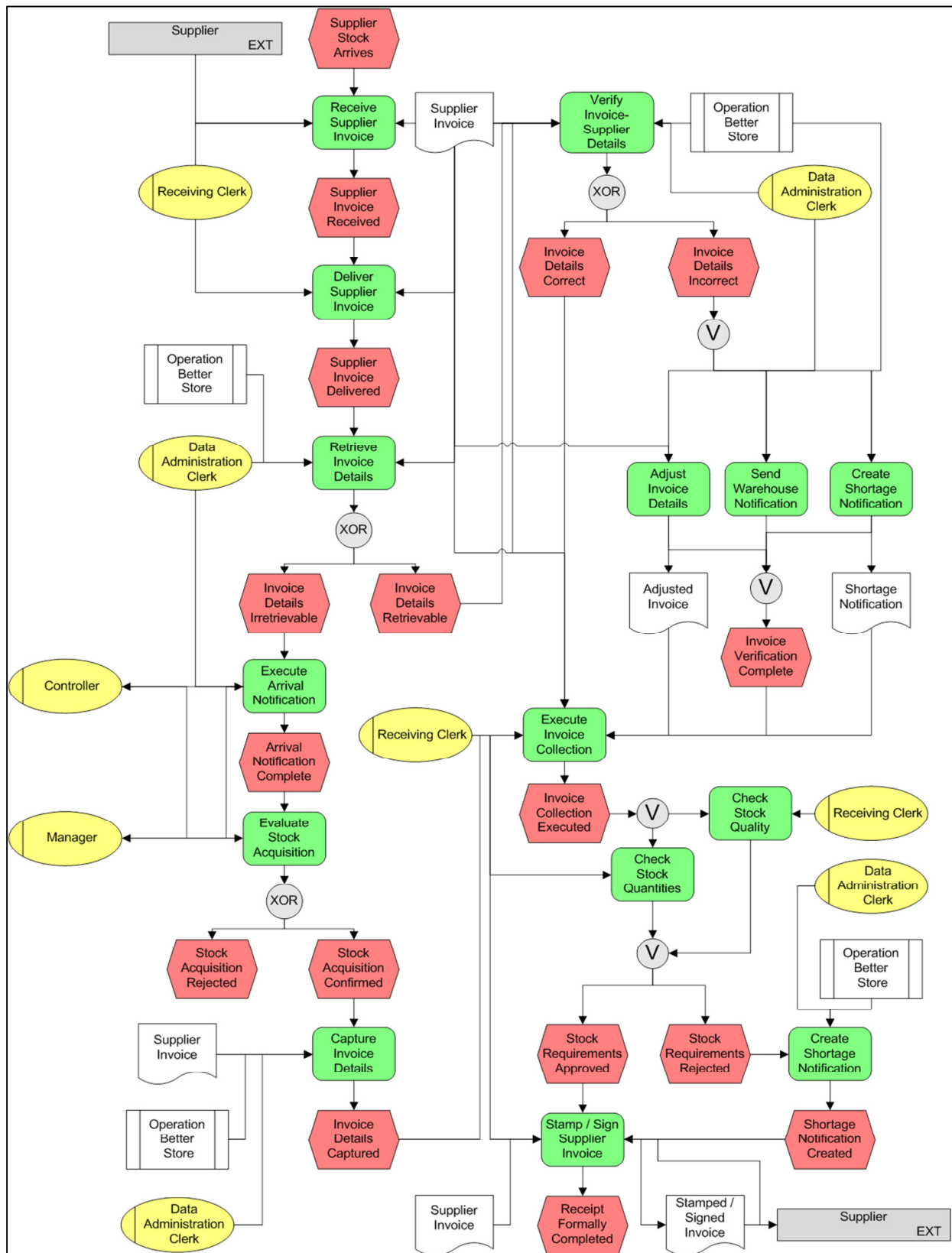


Diagram 32: EPC's - Receiving Process

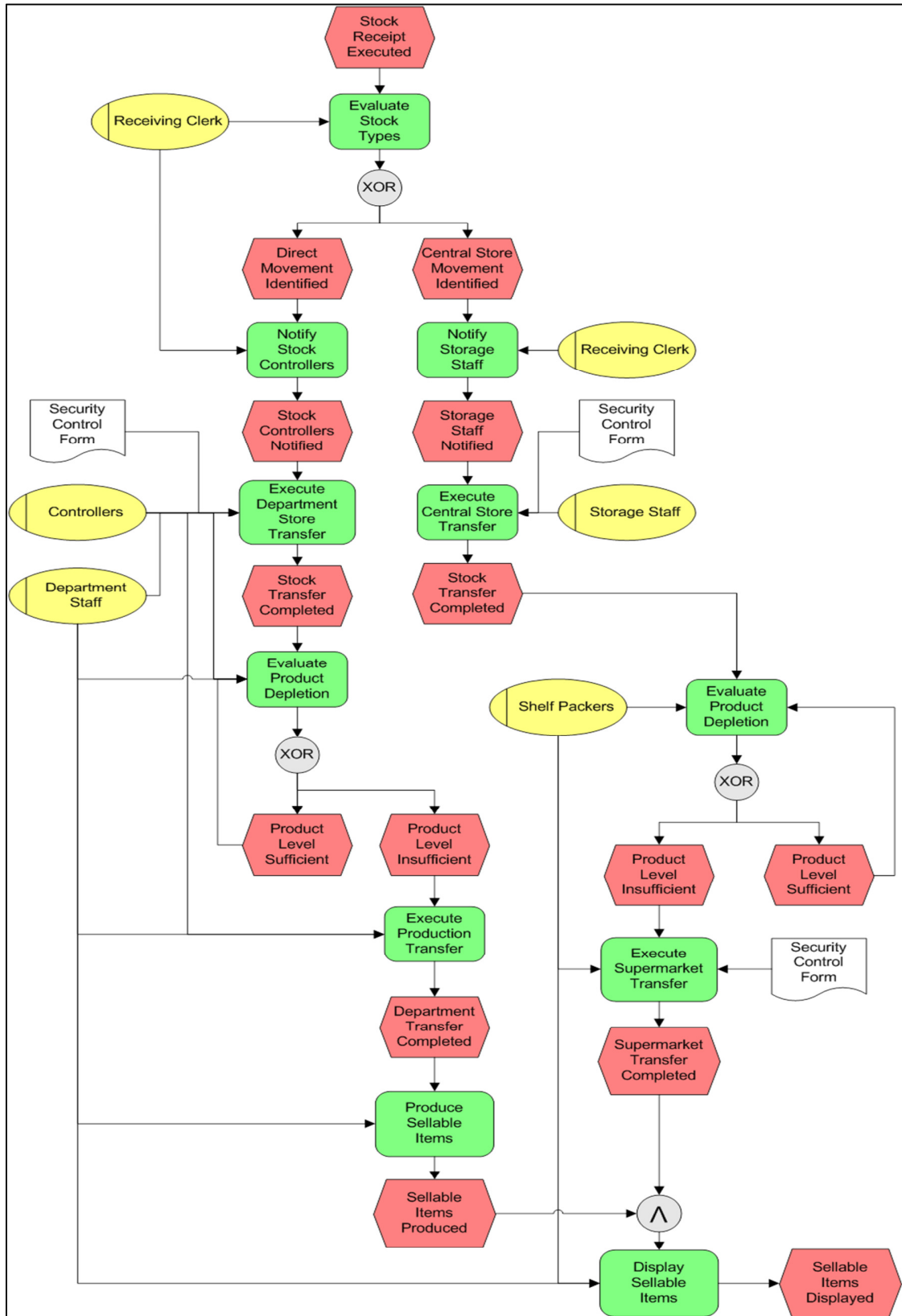


Diagram 33: EPC's- Transfer and Presentation Process



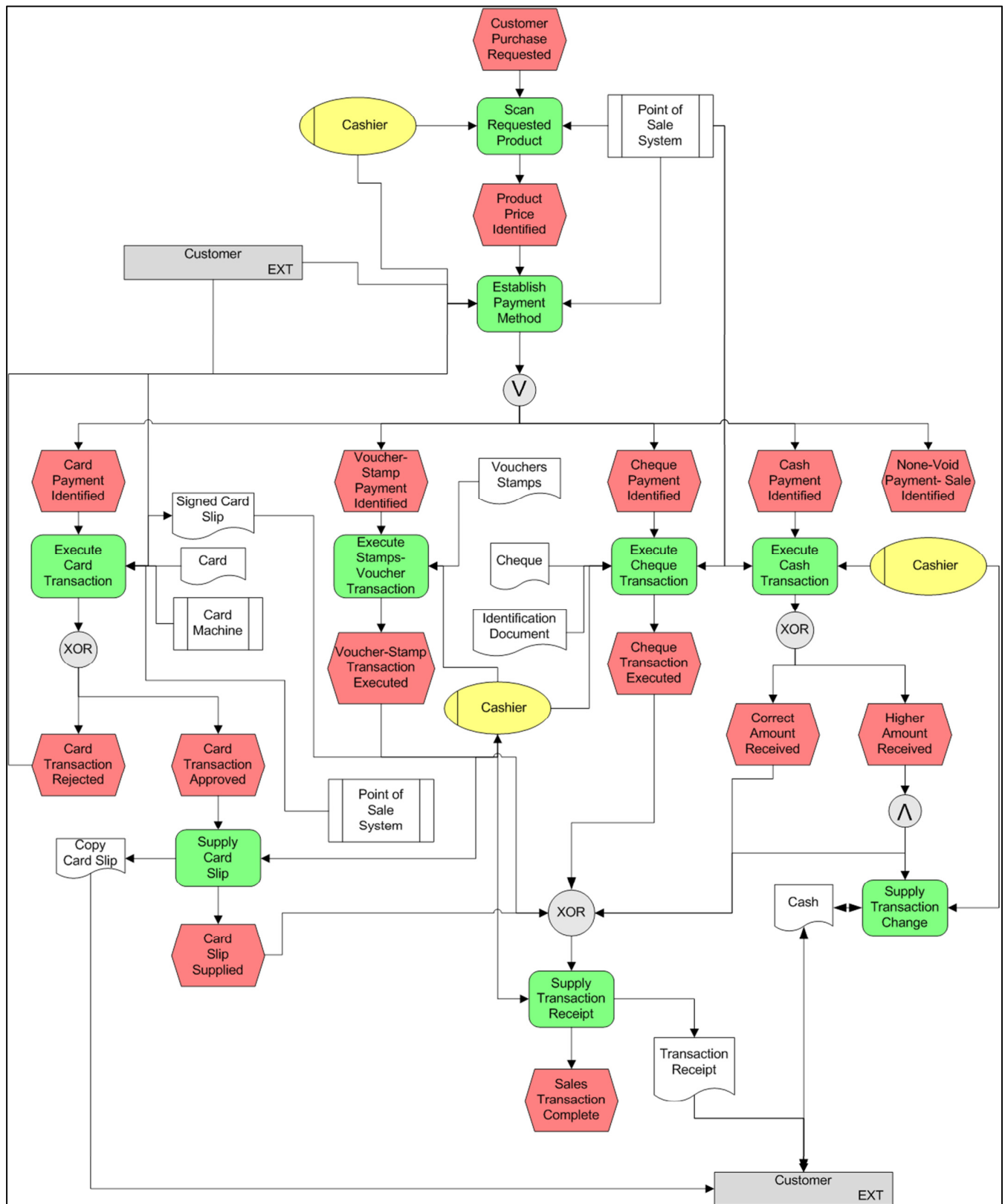


Diagram 34: EPC's - Sales Process

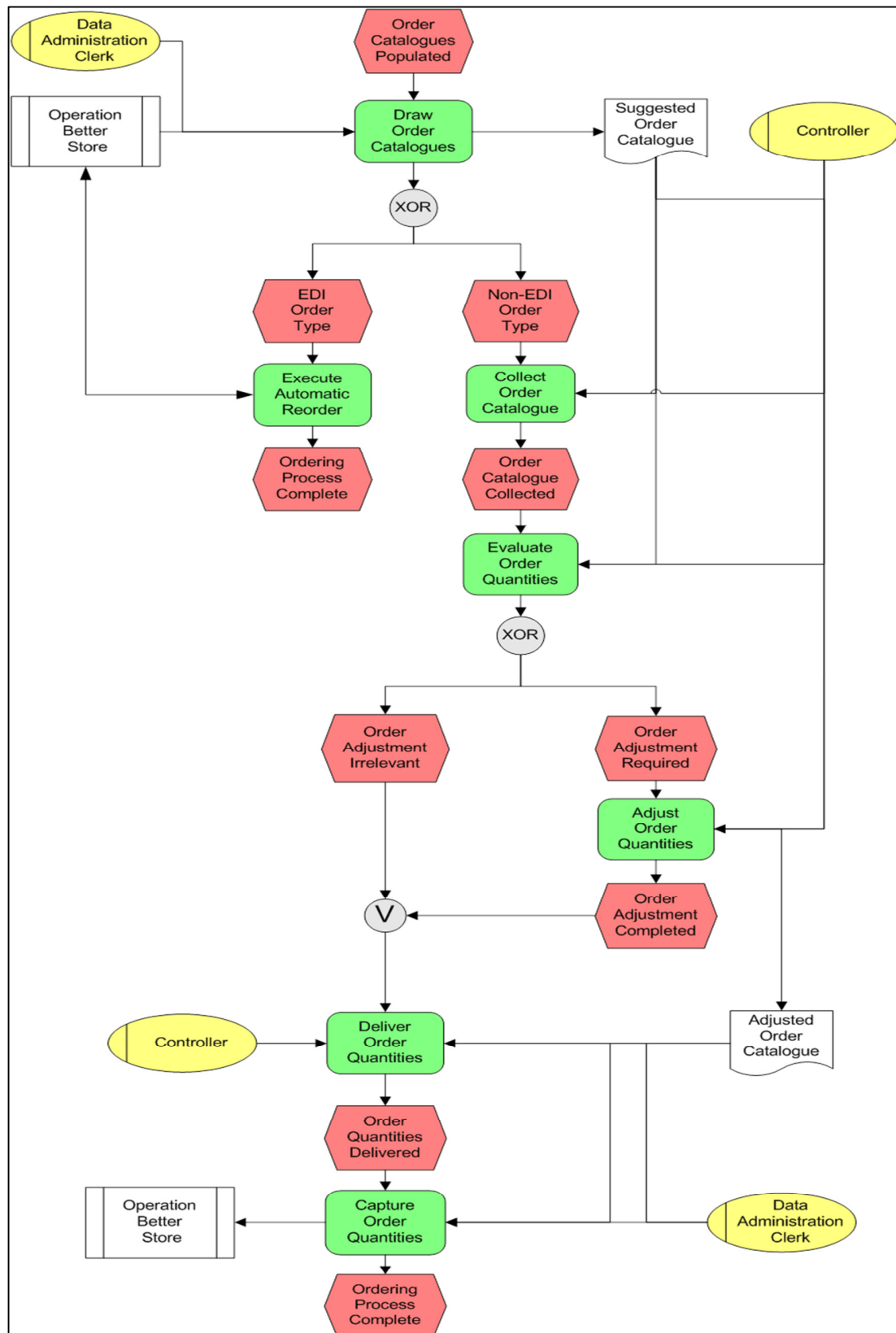


Diagram 35: EPC's - Ordering Process

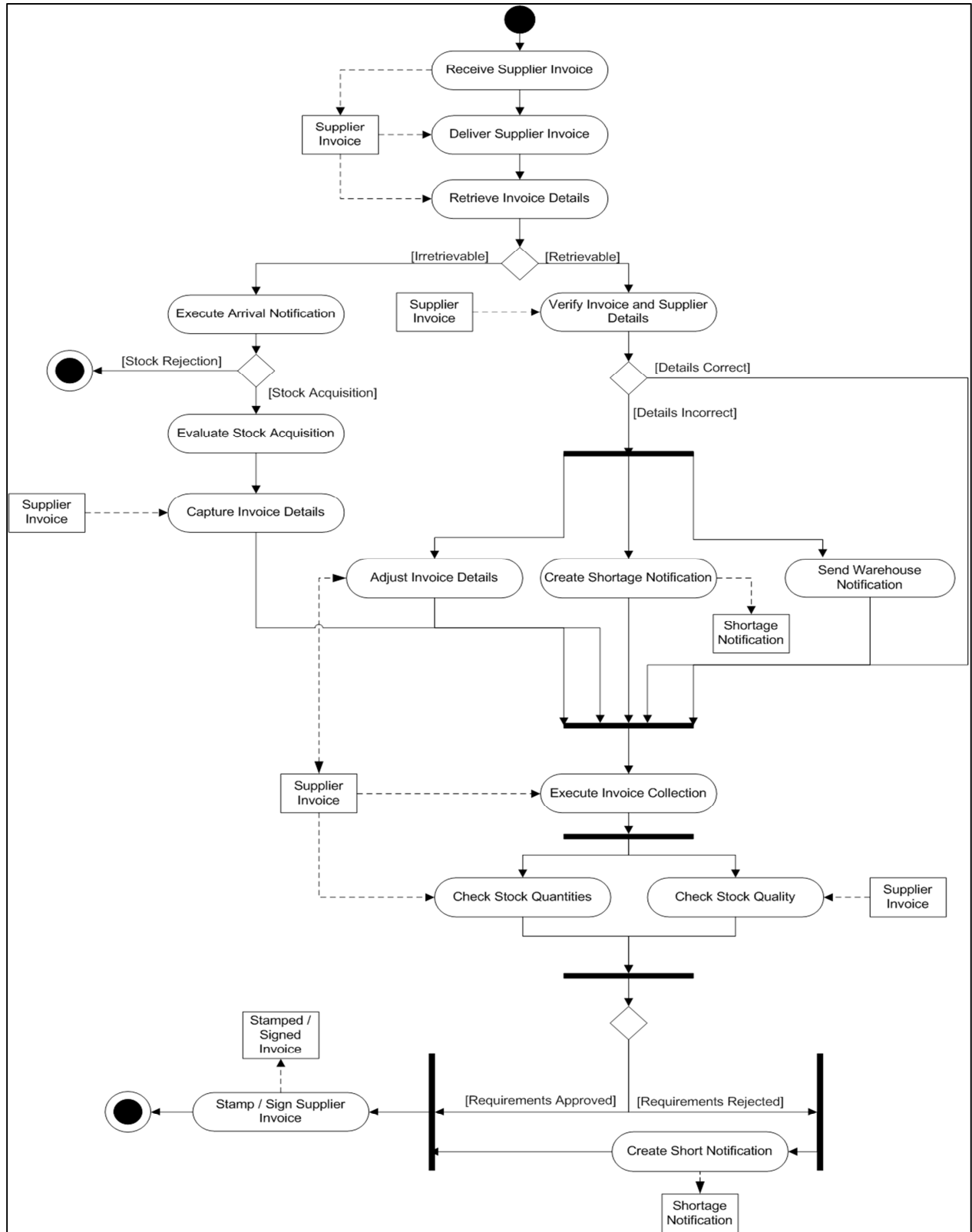


Diagram 36: UML-AD - Receiving Process

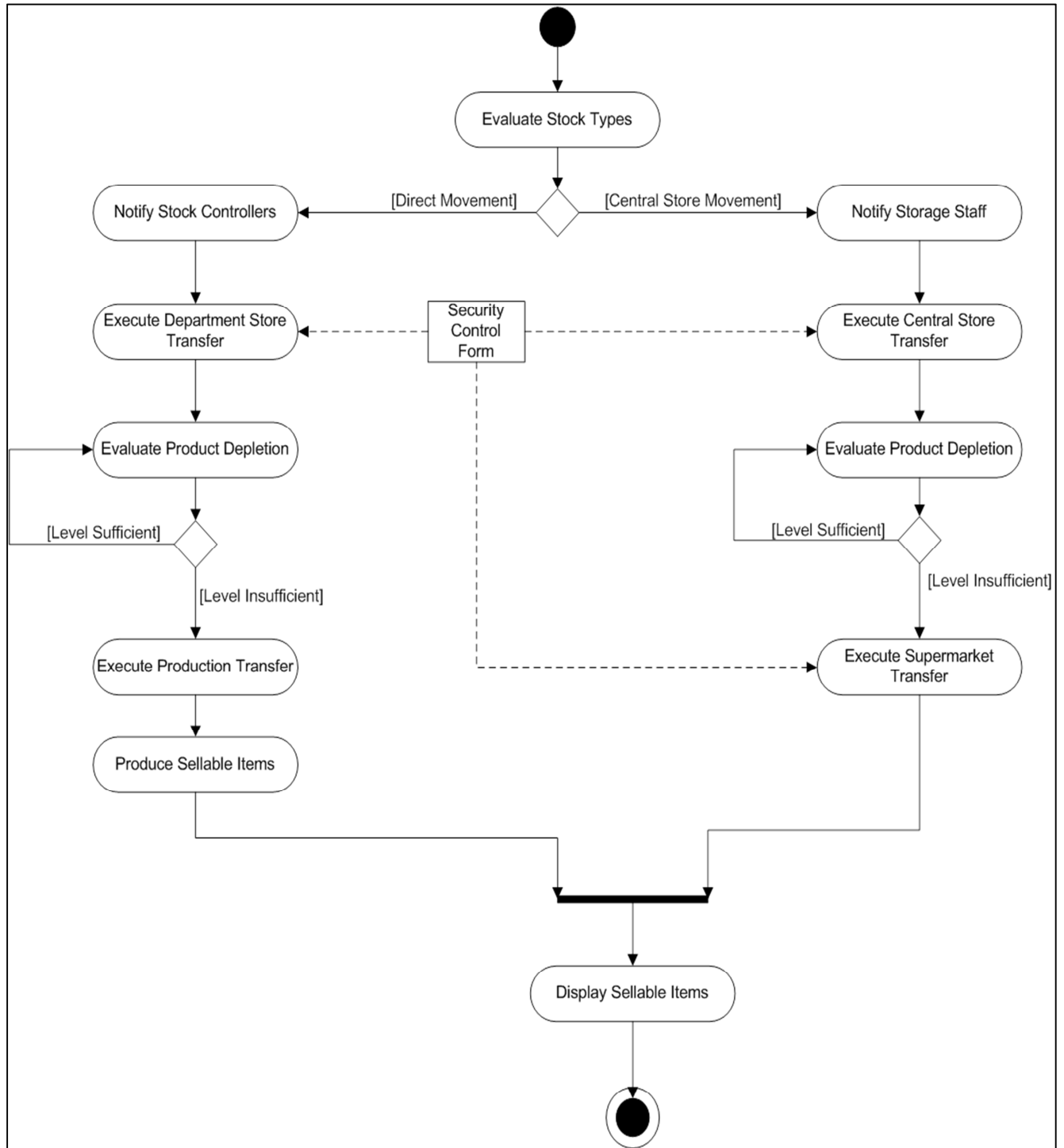


Diagram 37: UML-AD - Transfer and Presentation Process

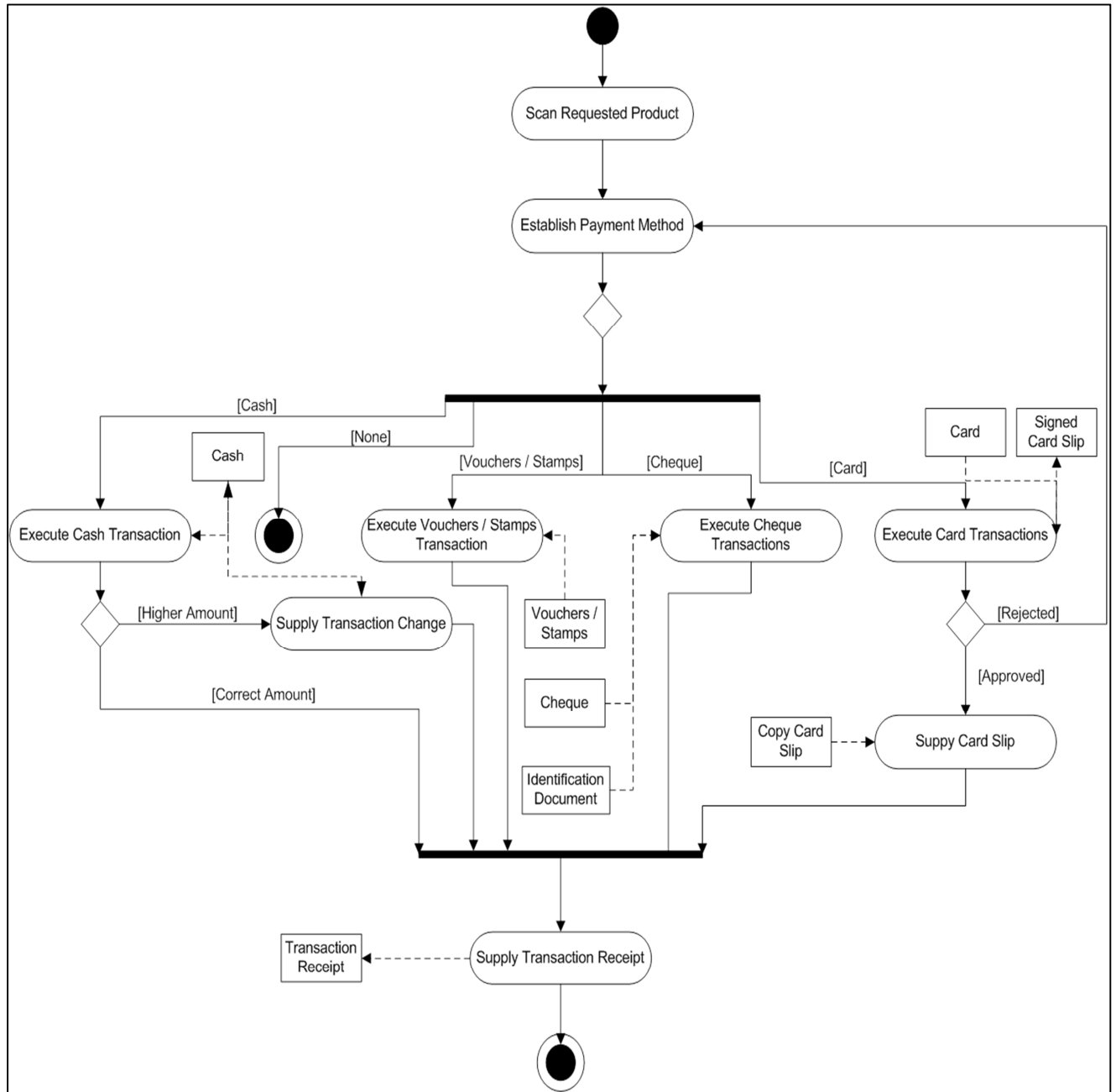


Diagram 38: UML-AD - Sales Process

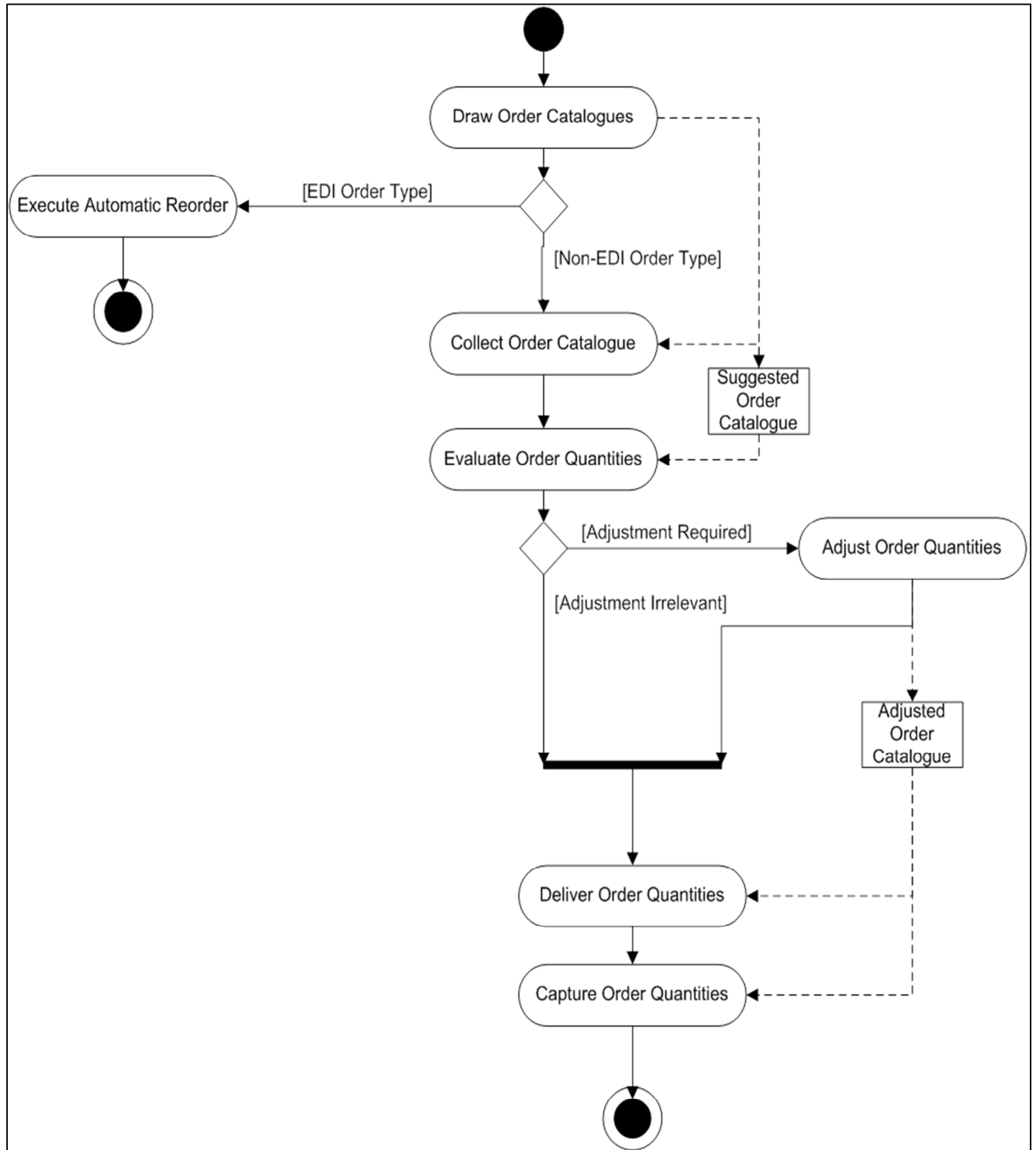


Diagram 39: UML-AD - Ordering Process

## 3.6. MEASURING THE SUITABILITY OF BUSINESS PROCESS MODELLING TECHNIQUES

*This section measures the suitability of each of the considered Business Process Modelling Techniques through the use of the developed measurement framework.*

The designed business process models enable an evaluation regarding the suitability of the considered Business Process Modelling Techniques. The suitability of each of these techniques is measured through the use of the developed measurement framework.

### 3.6.1. COMPLETENESS, ECONOMY AND GENERATING EFFICIENCY - MEASUREMENT INPUTS

In order to measure the completeness, economy and generating efficiency of each of the considered Business Process Modelling Techniques, it is necessary to determine specific measurement inputs.

These measurement inputs include:

- the type and counts of informational elements that are required
- the informational elements that are portrayed by the distinct sets of business process models
- the time that is required to design the distinct sets of business process models.

The type of informational elements that are required is derived from the scope of the relevant modelling application. Through a count-based analysis of the business process descriptions, the following counts regarding these required informational elements are determined:

**Table 5: Required Informational Elements**

		INFORMATIONAL ELEMENTS					
		EVENTS Start / End	ACTIVITIES	SEQUENCE OR INTERDEPENDENCE	CUSTOMERS OR RESPONSIBLE ENTITIES	INPUTS	OUTPUTS
RECEIVING		3	15	82	19	15	4
TRANSFER AND PRESENTATION		2	11	49	16	3	1
SALES		3	8	55	13	14	4
ORDERING		3	7	38	7	7	3
<b>TOTAL</b>	<b>382</b>	<b>11</b>	<b>41</b>	<b>224</b>	<b>55</b>	<b>39</b>	<b>12</b>

Through an analysis of the distinct sets of business process models, the following characteristics relevant to the considered techniques are determined:

- The business process models that were designed through the use of BPMN portray all of the required informational elements.
- The business process models that were designed through the use of EPC's portray all of the required informational elements. In addition, they portray intermediate events as well as their associated control flows.

- Through a count-based analysis of these intermediate events and their associated control flows, the counts related to these informational elements are identified:

These counts are depicted by the table below:

**Table 6: EPC's - Additional Informational Elements**

COUNT			ADDITIONAL INFORMATIONAL ELEMENTS	
			EVENTS Intermediate	SEQUENCE OR INTERDEPENDENCE
			RECEIVING	14
			TRANSFER AND PRESENTATION	12
			SALES	12
			ORDERING	7
	TOTAL	90	45	45

- The business process models that were designed through the use of UML-AD portray all of the required informational elements except for customers or responsible entities.
- The count related to these lacking informational elements can be derived from the table related to the required informational elements:

**Table 7: UML-AD - Lacking Informational Elements**

COUNT			LACKING INFORMATIONAL ELEMENTS	
			CUSTOMERS OR RESPONSIBLE ENTITIES	
			RECEIVING	19
			TRANSFER AND PRESENTATION	16
			SALES	13
			ORDERING	7
	TOTAL	55	55	55



- Based on a time study, the time required to design the distinct sets of business process models is determined. The table below depicts the results of this time study:

**Table 8: Business Process Models - Time Required**

	BPMN	EPC	UML
RECEIVING PROCESS	63	88	59
TRANSFER AND PRESENTATION	34	41	19
SALES	36	73	42
ORDERING PROCESS	26	46	23
<b>TOTAL</b>	<b>159</b>	<b>248</b>	<b>143</b>

### 3.6.2. COMPLETENESS, ECONOMY AND GENERATING EFFICIENCY - MEASUREMENT

Through the use of the aforementioned measurement inputs, the completeness, economy and generating efficiency of each of the considered Business Process Modelling Techniques is measured.

The table below consolidates the results of these measurements:

**Table 9: Measurements - Completeness, Economy and Generating Efficiency**

<b>COMPLETENESS</b>			
	BPMN	EPC	UML-AD
Orinf	381	381	381
Txrinf	381	381	326
<b>COMPLETENESS</b> <b><math>Txcomp = (Txrinf / Orinf)</math></b>	<b>1.00</b>	<b>1.00</b>	<b>0.86</b>
<b>ECONOMY</b>			
	BPMN	EPC	UML-AD
Orinf	381	381	381
Txainf	381	471	326
<b>ECONOMY</b> <b><math>Txecon = 2 - (Txrinf / Orinf)</math></b>	<b>1.00</b>	<b>0.76</b>	<b>1.00</b>
<b>GENERATING EFFICIENCY</b>			
	BPMN	EPC	UML-AD
Txrinf	381	381	381
Txtime	159	248	143
Txegen	2.3962	1.5363	2.6643
<b>GENERATING EFFICIENCY</b> <b><math>Txegeff = (Txegen / (\max\{T\{A;B;C;.....;X\}egen\}))</math></b>	<b>0.90</b>	<b>0.58</b>	<b>1.00</b>

### 3.6.3. EASE OF UNDERSTANDING - MEASUREMENT INPUTS

In order to measure the ease of understanding associated with each of the considered techniques, it is necessary to first determine the following measurement inputs:

#### 1. Theoretical ease of understanding

Based on the aforementioned relationship between the measurements of economy, least complexity and theoretical ease of understanding, the economy of each of the considered techniques is used as a measure of their theoretical ease of understanding.

#### 2. Practical ease of understanding

The results of the executed survey are used to measure the practical ease of understanding associated with each of the considered techniques. The table below presents the results of this survey as well as the relevant participants:

**Table 10: Ease of Understanding - Practical Survey**

PARTICIPANT (N)	RANK- PREFERRED TECHNIQUE			ORGANIZATION ENTITY	COUNT
	1	2	3		
1	UML	BPMN	EPC	RECEIVING CLERK	3
2	UML	BPMN	EPC	DATA ADMINISTRATION CLERK	3
3	UML	BPMN	EPC	BRANCH MANAGER	1
4	UML	BPMN	EPC	CONTROLLERS	8
5	BPMN	UML	EPC	DEPARTMENT STAFF	3
6	UML	BPMN	EPC	STORAGE STAFF	3
7	UML	BPMN	EPC	SHELF PACKER	2
8	UML	BPMN	EPC	CASHIER	2
9	UML	BPMN	EPC		
10	BPMN	UML	EPC		
11	BPMN	UML	EPC		
12	UML	BPMN	EPC		
13	UML	BPMN	EPC		
14	UML	BPMN	EPC		
15	UML	BPMN	EPC		
16	UML	BPMN	EPC		
17	UML	BPMN	EPC		
18	UML	BPMN	EPC		
19	UML	BPMN	EPC		
20	UML	BPMN	EPC		
21	UML	BPMN	EPC		
22	UML	BPMN	EPC		
23	UML	BPMN	EPC		
24	UML	BPMN	EPC		
25	UML	BPMN	EPC		

The participants of the survey represent a random sample of the organizational entities responsible for the execution of the core business processes within the Checkers Supermarket – Stellenbosch. It is argued that these entities should represent appropriate survey participants given that they are exposed and contribute to these implemented and executed business processes on a daily basis.

Given the business process maturity of the Checkers Supermarket – Stellenbosch (with particular reference to the lack of the formal measurement, analysis and control of their core business processes), it is difficult to predict the future entities that will be responsible for the measurement, analysis and control of their core business processes. It is therefore difficult to isolate possible survey participants beyond those that execute the core business processes.

### 3.6.4. EASE OF UNDERSTANDING - MEASUREMENT

Based on the results of the practical and theoretical ease of understanding measurements, the ease of understanding of each of the considered techniques is measured. The table below depicts the results of these measurements:

Table 11: Measurement - Ease of Understanding

<b>THEORETICAL EASE OF UNDERSTANDING</b>			
	BPMN	EPC	UML-AD
Txecon	1.00	0.76	1.00
<b>EASE OF UNDERSTANDING</b> Txeund = Txecon	1.00	0.76	1.00
<b>PRACTICAL EASE OF UNDERSTANDING</b>			
	BPMN	EPC	UML-AD
Orinf	4	0	21
<b>EASE OF UNDERSTANDING</b> Txeund = (Txcund / (max{T{A;B;C;.....;X}cund}))	0.19	0.00	1.00
<b>CONSOLIDATED EASE OF UNDERSTANDING</b>			
	BPMN	EPC	UML-AD
<b>EASE OF UNDERSTANDING =</b> <b>((0.5)PRACTICAL)+ ((0.5)THEORETICAL)</b>	0.60	0.38	1.00

### 3.6.5. FORMALITY, SOFTWARE SUPPORT AND SUSTAINABILITY - MEASUREMENT INPUTS

In order to measure the formality relevant to each of the considered techniques, the following measurement inputs are identified:

- BPMN's full set of elements contains 37 distinct notational semantics.
- EPC's extended set of elements contains 14 distinct notational semantics.
- While collectively UML possess a rich set of semantics, only 12 distinct notational elements are relevant to UML-AD.

In order to measure the software support relevant to each of the considered techniques, the following information and measurement inputs are identified:

- Shoprite Checkers Pty Ltd. uses SAP as its preferred Enterprise Resource Planning (ERP) resource. Examining the modules of SAP, the following is identified:
  - BPMN can be integrated and supported by SAP.
  - EPC's, as part of the ARIS Toolset, can be integrated and supported by SAP.
  - Although various members of the UML family can be integrated and supported by SAP, UML-AD is currently not integrated and supported by SAP.

### 3.6.6. FORMALITY, SOFTWARE SUPPORT AND SUSTAINABILITY - MEASUREMENT

In light of the identified measurement inputs, the formality, software support and sustainability of each the considered techniques is measured. The results of these measurements are presented below:

Table 12: Measurement - Formality, Software Support and Sustainability

<b>FORMALITY</b>			
	BPMN	EPC	UML-AD
$T_{xsem}$	37	14.00	12.00
<b>FORMALITY</b> $T_{xform} = (T_{xsem} / (\max\{T\{A;B;C;.....;X\}_{sem}\}))$	1.00	0.38	0.32
<b>SOFTWARE SUPPORT</b>			
	BPMN	EPC	UML-AD
$T_{xyint}$	1	1	0
<b>SOFTWARE SUPPORT</b> $T_{xsoft} = t$	1.00	1.00	0.00
<b>SUSTAINABILITY</b>			
	BPMN	EPC	UML-AD
<b>SUSTAINABILITY =</b> $((0.5)FORMALITY + ((0.5)SOFTWARE SUPPORT))$	1.00	0.69	0.16

### 3.6.7. EASE OF USE, EFFECTIVENESS AND SUITABILITY - MEASUREMENT

Upon completion of all the other measurements, the measurements regarding the ease of use, effectiveness and suitability of each of the considered techniques are executed. These measures denote a consolidation of all the other measured characteristics in conjunction with their assigned weight

distributions. The table below depicts the ease of use, effectiveness and suitability of each of the considered Business Process Modelling Techniques:

**Table 13: Measurement – Ease of Use, Effectiveness and Suitability**

		CHARACTERISTIC CONTRIBUTION TO OVERALL SUITABILITY	BPMN SCORE	BPMN CONTRIBUTION	EPC SCORE	EPC CONTRIBUTION	UML SCORE	UML CONTRIBUTION
<b>SUITABILITY</b>	SOFTWARE SUPPORT	0.1250	1.0000	0.1250	1.0000	0.1250	0.0000	0.0000
	FORMALITY	0.1250	1.0000	0.1250	0.3800	0.0475	0.3200	0.0400
	PRACTICAL EASE OF UNDERSTANDING	0.1250	0.1900	0.0238	0.0000	0.0000	1.0000	0.1250
	THEORETICAL EASE OF UNDERSTANDING	0.1250	1.0000	0.1250	0.7600	0.0950	1.0000	0.1250
	ECONOMY	0.1250	1.0000	0.1250	0.7600	0.0950	1.0000	0.1250
	COMPLETENESS	0.2500	1.0000	0.2500	1.0000	0.2500	0.8600	0.2150
	SUSTAINABILITY	0.2500	1.0000	0.2500	0.6900	0.1725	0.1600	0.0400
	GENERATING EFFICIENCY	0.2500	0.9000	0.2250	0.5800	0.1450	1.0000	0.2500
	EASE OF UNDERSTANDING	0.2500	0.6000	0.1500	0.3800	0.0950	1.0000	0.2500
	EFFECTIVENESS	1.0000	0.8750	0.8750	0.6625	0.6625	0.7550	0.7550
	EASE OF USE	1.0000	0.8750	0.8750	0.6625	0.6625	0.7550	0.7550
	<b>BPMN</b>	<b>87.50%</b>						
	<b>EPC</b>	<b>66.25%</b>						
	<b>UML</b>	<b>75.50%</b>						

## CHAPTER 4: CONCLUSION

*This section presents the conclusions and recommendations of the research study.*

### 4.1. SELECTING THE MOST SUITABLE BUSINESS PROCESS MODELLING TECHNIQUE

It is suggested that a Business Process Modelling Technique is eventually considered suitable if it possesses the capability to create business process models that enable the relevant organization to achieve its modelling objectives. This implies that a Business Process Modelling Technique must first be regarded as effective before it can be regarded as suitable. In turn, it is suggested that a Business Process Modelling Technique can be regarded as effective if it can create business process models that are complete, efficiently generated, easy to understand and sustainable. Collectively, these four characteristics represent the ease with which a Business Process Modelling Technique can be used to design and support effective business process models.

Considering the above perspectives and the results of the suitability evaluations, it is concluded that:

- Business Process Modelling Notation (BPMN) is the most suitable technique for this specific modelling application.
- The set of business process models that are designed through the use Business Process Modelling Notation signifies the most suitable representation of the “as-is” business processes for this specific modelling application.

These conclusions are motivated by:

- BPMN’s measured capability in terms of effectiveness and ease of use for this specific modelling application.
- BPMN’s measured capability in terms of generating efficiency, sustainability, completeness and ease of understanding for this specific modelling application.

### 4.2. GENERIC USE OF BUSINESS PROCESS MODELS

Considering that the various supermarkets of Shoprite Checkers (Pty) Ltd. should share the same strategic and operational objectives, it is fair to argue that their business processes should be the same.

Given that their business processes should be the same, it is also fair to argue that their modelling requirements should be the same.

Based on these views, it is concluded that:

- The business process models of Checkers Supermarket – Stellenbosch should be representative of the business process models of any of the other supermarkets of Shoprite Checkers (Pty) Ltd.
- The business process models of Checkers Supermarket – Stellenbosch can be used as a platform to standardize and roll-out the relevant business processes to the various other supermarkets of Shoprite Checkers (Pty) Ltd.
- The use of Business Process Modelling Notation to design business process models should lead to the most suitable representation regarding the business processes of any of the other supermarkets of Shoprite Checkers (Pty) Ltd.

## **4.3. CONTINUOUS IMPROVEMENT AND MANAGEMENT OF BUSINESS PROCESSES**

The designed business process models enable the Checkers Supermarket – Stellenbosch to understand their core business processes. In turn, this provides them with a platform to properly and continuously execute, measure, analyze, improve and control these business processes.

## **4.4. RECOMMENDATIONS**

The following recommendations are identified:

1. Business Process Modelling should be used to define, document and standardize the business processes of all the supermarkets of Shoprite Checkers (Pty) Ltd. In addition, the progress of these actions should be monitored and driven during the next few years.
2. Business Process Modelling Notation should be used as the preferred Business Process Modelling Technique for any future modelling projects relevant to the Checkers Supermarket – Stellenbosch.
3. Business Process Modelling Notation should be used as the preferred Business Process Modelling Technique for any future modelling projects relevant to the others supermarkets of Shoprite Checkers (Pty) Ltd.

4. The business processes of the Checkers Supermarket – Stellenbosch should be actively managed in order to instill a culture of continuous improvement.
5. Similar studies should be executed in order to establish a repository of scenarios where certain Business Process Modelling Techniques will be suitable for specific modelling applications.



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# ADDENDUM 1

Table 13: List of "Group B" Literature

Activity Labeling in Business Process Modelling
Business Intelligence
Business Process Change
Business Process Design, Analysis and Optimization
Business Process Innovation
Business Process Modelling Tools
Business Process Reengineering
Coupling Metrics
Customer Relationship Management
Dimensions of Business Process Quality
Document Analysis
General Modelling and Visualization
Guidelines of Modelling Frameworks
Information
Information Management
Information Systems Development
Interview Recommendations
ISO9001
Knowledge
Knowledge Management
Lean Management
Ontologic Metrics
Systems Modelling and Development
The CAP Framework of Modelling
Value Stream Management
Work Flow Management



## ADDENDUM 2

Table 14: "Group 1" Techniques

ADONIS
AMBER
Booch's OOD
Business Process Execution Languages (BPEL)
Business Process Modelling Notation (BPMN)
Data Flow Diagram (DFD)
Entity Relationship Diagrams
Event-Driven Process Chains (EPC)
Function Trees
Gantt Chart
Graham Detail Process Charts
GRAI-GIM
Integrated Modelling Definition Methods (IDEF)
OORAM
Petri Nets
Process Specification Language (PSL)
Role Activity Diagrams (RAD)
Role Interaction Diagrams (RID)
RosettaNet
SIPOCS
Structured Analysis and Design Technique (SADT)
Unified Modelling Languages (UML)
Value Stream Mapping (VSM)
XML Process Definition Language (XPDL)
Yet Another Modelling Language (YAWL)